The Journal of Bone and Joint Surgery

The Official Publication of

The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
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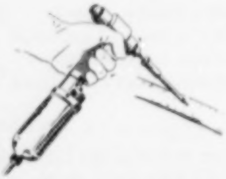

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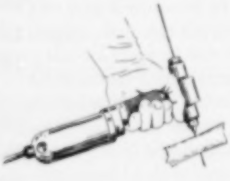

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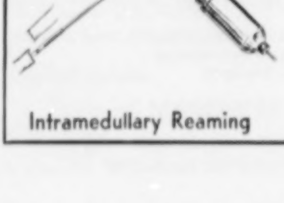

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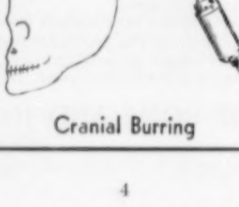

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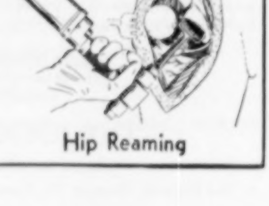

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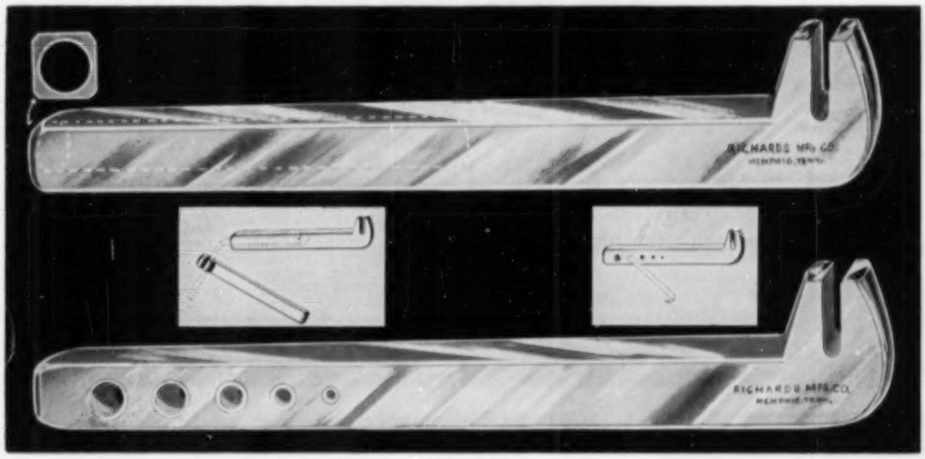

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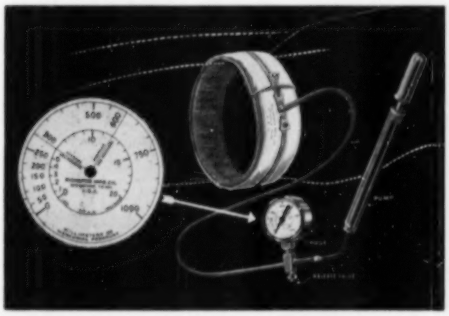

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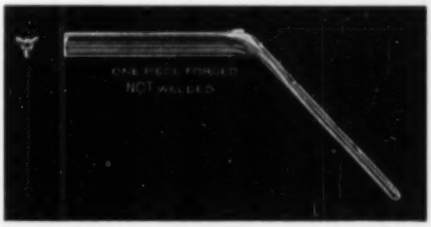

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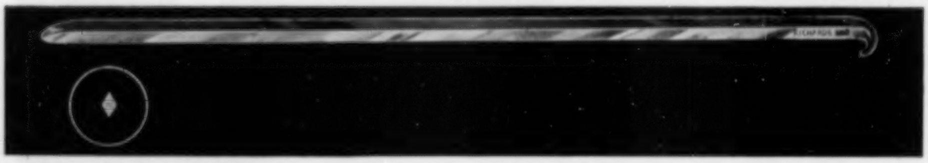

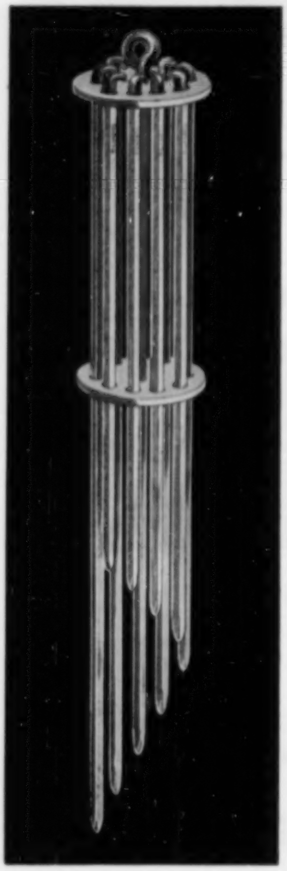

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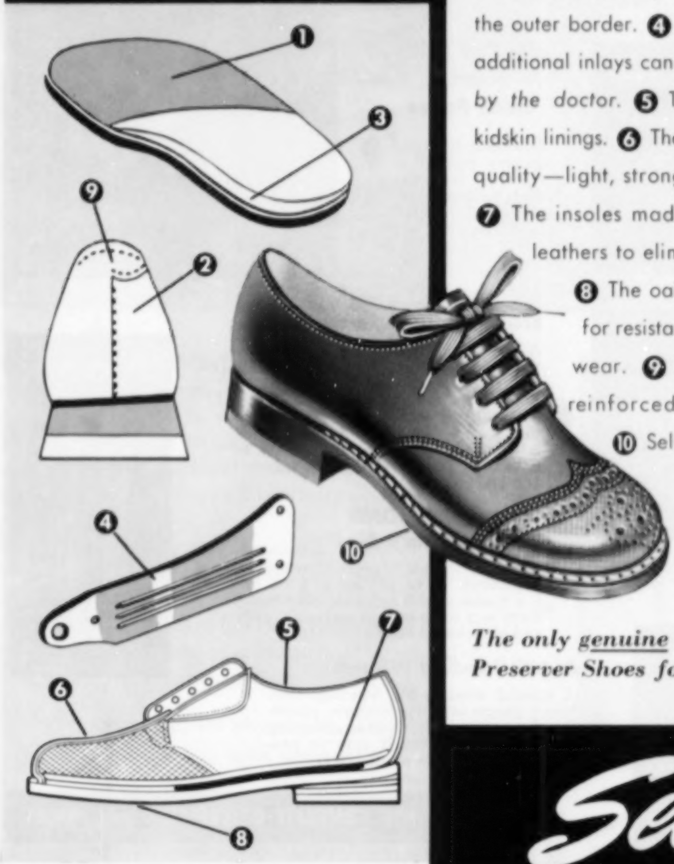

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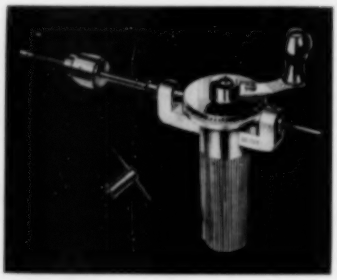

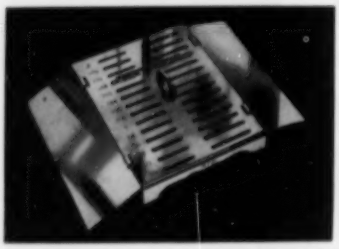

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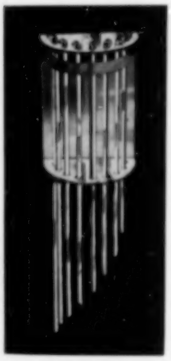

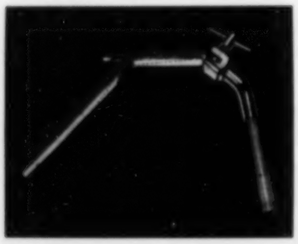

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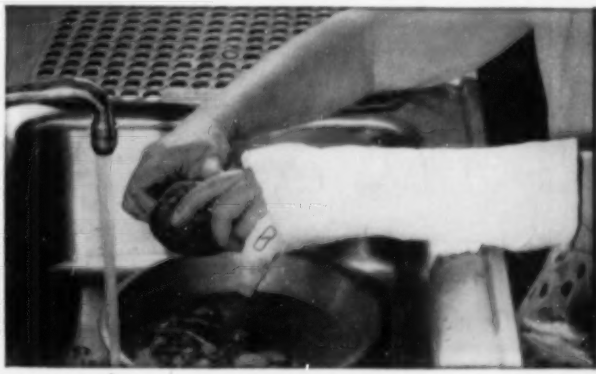

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lighter, less fatiguing shoulder spica of MELMAC BANDAGE. Encourages prescribed exercise. Shortens hospital stay. Makes care easier. Bandage for bandage, MELMAC BANDAGE has 2 to 4 times the strength of ordinary plaster—is self-mending in the early molding stage. Fashion these better plastic casts with fewer bandages. ▶

Easy to apply and remove. 1. Just dip MELMAC BANDAGE into tepid water for 5 to 10 seconds. Squeeze out excess water thoroughly. Apply. 2. Use about half the usual number of rolls (or less). 3. Dispose of waste the same as with ordinary plaster. There is less mess. 4. Remove the thin cast easily with cast cutter, knife or cast saw. Send for sample.

Sensitivity: Since this product may contain traces of formaldehyde, persons who are known to be sensitive to it should be observed closely for dermatitis. Operators using the bandage repeatedly should wear rubber gloves if skin sensitivity exists.

Patent Applied For

Davis & Geck

MELMAC®

resin plaster of Paris **BANDAGE**

Davis & Geck, Inc., a unit of American Cyanamid Company, Danbury, Connecticut.
Sutures and other surgical specialties

Upjohn

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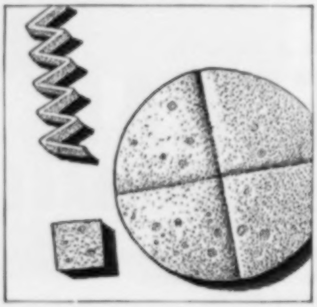

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FAST-SETTING
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4" WIDE
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better patient cooperation
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Under proper medical supervision, "Trilene" may be self administered by the patient, adult or child, with relatively wide margin of safety.[1,2] IN OBSTETRICS, relief of pain has been found highly satisfactory when "Trilene" was employed with a suitable inhaler either alone during labor, or in association with pudendal block or low spinal anesthesia for delivery.[2,3] IN MINOR SURGERY, "Trilene" analgesia has also been successfully employed for relief of pain during the treatment and management of burns, suturing of lacerations, removal of painful dressings, cystoscopies, biopsies, and orthopedic manipulations.[1,2]

"Trilene"®
Brand of trichloroethylene U.S.P. (Blue)

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With "Trilene," self administered with a suitable inhaler, induction of analgesia is usually smooth and rapid with minimum or no loss of consciousness. If unconsciousness occurs, inhalation is automatically interrupted. Nausea and vomiting seldom occur. "Trilene" is recommended for analgesia only, not for anesthesia nor for the induction of anesthesia. Epinephrine is contraindicated when "Trilene" is employed. "Trilene" is nonexplosive.

"Trilene" is supplied in 300 cc. containers, 15 cc. tubes, and 6 cc. ampuls.

Literature available on request.

1. Brown, S., and Fehlman, B. F.: Missouri Med. *50*:609 (Aug.) 1953.
2. Stephen, C. R., Nowill, W. K., and Martin, R.: Anesthesiology *13*:646 (Nov.) 1952.
3. Flowers, C. E., Jr.: Am. J. Obst. & Gynec. *65*:1027 (May) 1953.

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No. 577A, large, 6½" bar, 5" foot plate.
No. 577B, medium, 5½" bar, 4" foot plate.
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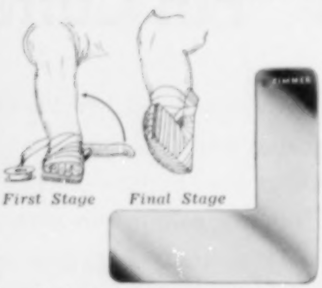

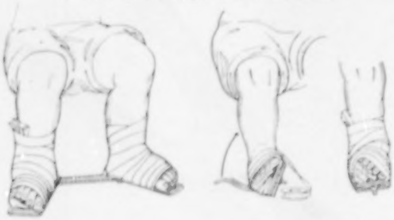

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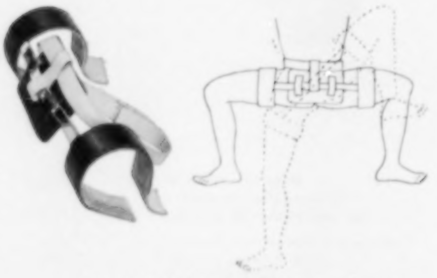

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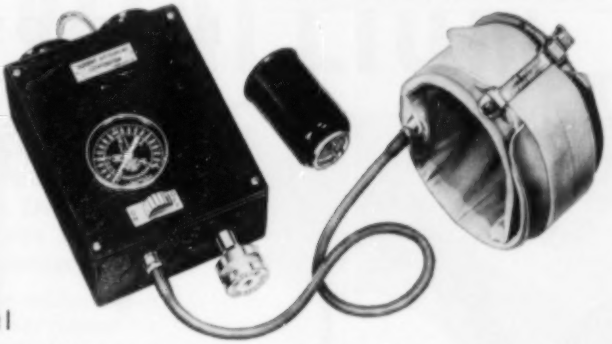

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Automatic quick inflation of cuff.

The pressure is governed by the control knob to desired setting on the dial and is absolutely maintained constant until changed by turning the control knob or released by pushing the ON-OFF valve.

For the first time the pressure may be varied at will during surgery.

Reliable in maintaining set pressure. No danger of loss of pressure, even if Freon container is removed or changed. No need constantly to watch accurate dial.

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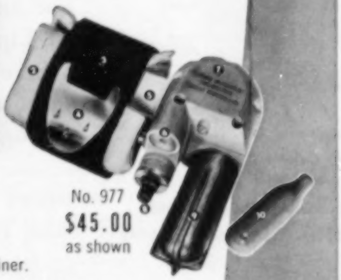

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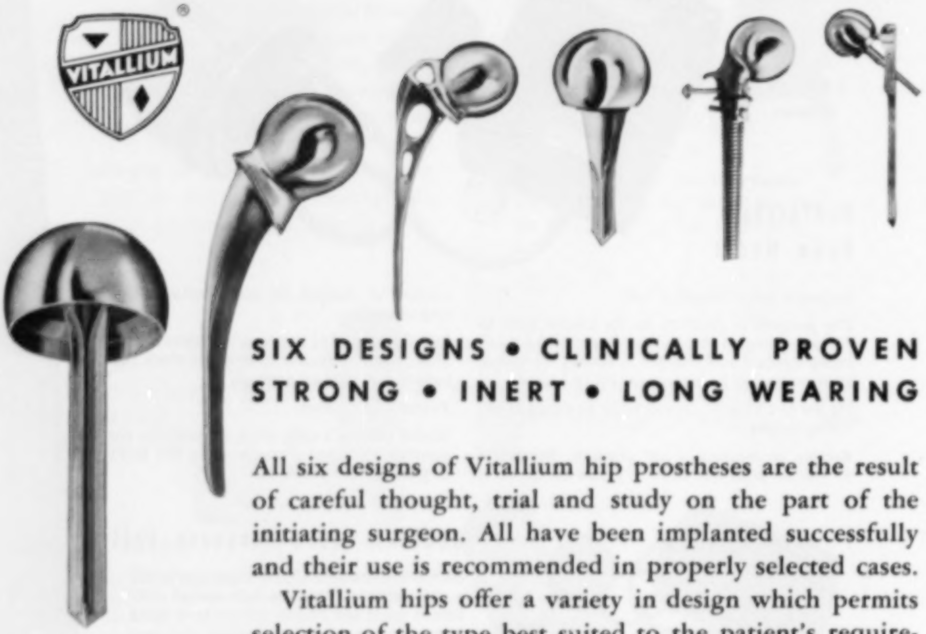

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Moreover, internal fixation of hip fractures promotes earlier ambulation of the patient. The Vitallium Jewett-Type appliance, designed specifically for this purpose, has proved itself. It is a strong, one-piece rigid cast appliance which has been used successfully for over 10 years in thousands of hip fractures.

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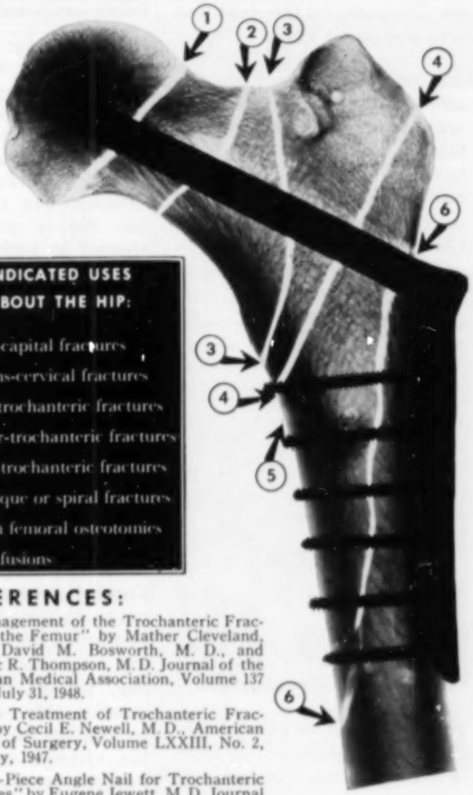

INDICATED USES ABOUT THE HIP:

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2 Trans-cervical fractures
3 Per-trochanteric fractures
4 Inter-trochanteric fractures
5 Sub-trochanteric fractures
6 Oblique or spiral fractures
7 High femoral osteotomies
8 Hip fusions

REFERENCES:

*1. "Management of the Trochanteric Fracture of the Femur" by Mather Cleveland, M. D., David M. Bosworth, M. D., and Frederic R. Thompson, M. D. Journal of the American Medical Association, Volume 137 No. 14, July 31, 1948.

2. "The Treatment of Trochanteric Fractures" by Cecil E. Newell, M. D., American Journal of Surgery, Volume LXXIII, No. 2, February, 1947.

3. "One-Piece Angle Nail for Trochanteric Fractures" by Eugene Jewett, M. D. Journal of Bone and Joint Surgery, Volume 23 No. 4, October, 1941.

4. "The Treatment of Intertrochanteric Fractures of the Femur" by Walter G. Stuck, M.D. Surgery, Volume 15 No. 2, February, 1944.

5. "Introchanteric Fractures of the Femur" by Mather Cleveland, M. D., David M. Bosworth, M. D. and Frederic R. Thompson, M. D. The Journal of Bone and Joint Surgery, Volume 29 No. 4, October, 1947.

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The Clinical Approach at the Woodrow Wilson Rehabilitation Center, Fisherville, Virginia, features the Clinical Team—the *Orthopedist*, the *Prosthetic Technician* (a HANGER Certified Prosthetist), the *Physical Therapist*, and the *Occupational Therapist* (for arm amputees only).

All amputee patients are examined by this Clinical Team with the complete medical history and other records at hand. During the examination the patient is analyzed as an individual case with his particular advantages and limitations evaluated in relation to the possible courses of treatment. For example, whether a particular stump or joint condition can be corrected with therapy, or with special prosthesis fitting and construction; if not, is further surgery desirable. Then a course of rehabilitation is prescribed by the Orthopedist, including the Physical (and Occupational for arm amputees) Therapy necessary, the type of Prosthesis to be worn, and other special treatment or training required.

Immediately the patient's treatment by the Center begins according to the Prescription. The patient receives pre-prosthetic therapy in which the stump is conditioned to provide the most efficient use of the Prosthesis. He is supervised and treated in baths, heat, exercise, etc., by therapists and nurses specially-trained for this work.

When the patient actually begins tc wear the prosthesis, the Clinical Team again works closely together in the rehabilitation program. The Prosthesis itself has been fabricated according to the measurements and specifications taken by the Prosthetist member of the Clinical Team. Careful attention is now given to fitting adjustments, continued therapy, and training exercises, such as walking, sitting, steps, etc. Unusual problems are cause for a complete review and possible change of prescription. For arm amputees, Occupational Therapy now becomes important, and the amputee spends part of each day learning to use the Prosthesis and to live an independent life. Trained Therapists and nurses supervise the teaching of dexterity and manipulation through blocks, games, doorknobs, faucets, tools, etc.

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TOWER

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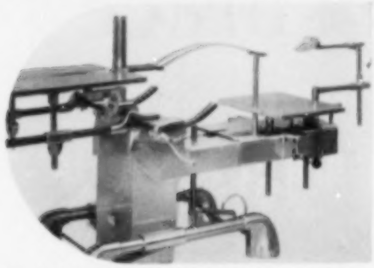

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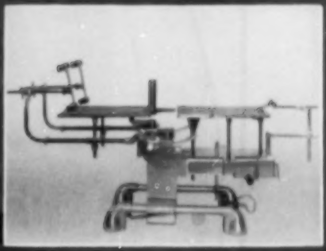

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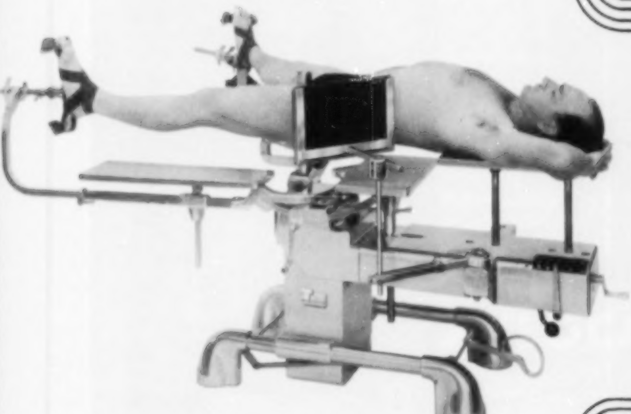

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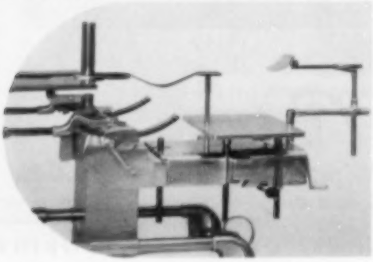

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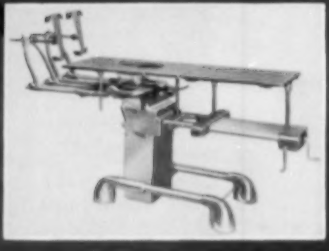

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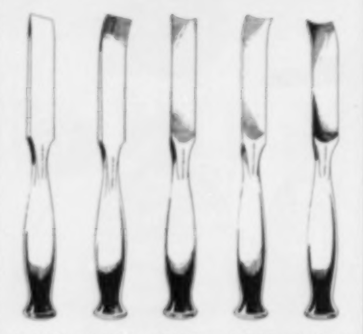
SMITH-PETERSEN OSTEOTOMES and GOUGES



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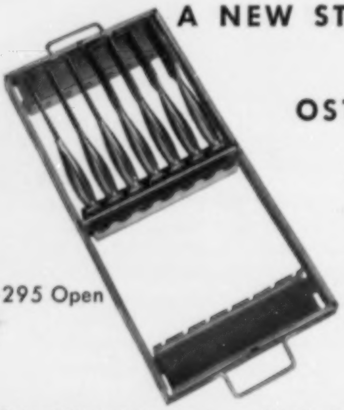
A NEW STAINLESS STEEL CASE TO HOLD SMITH-PETERSEN OSTEOTOMES and GOUGES



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0-295 Closed

CASE 0-295—holds seven Smith-Petersen Osteotomes.

CASE 0-296—holds seven Smith-Petersen Gouges.

CASE 0-297—holds a combination of seven Osteotomes and Gouges.

Cutting edges are protected at all times.
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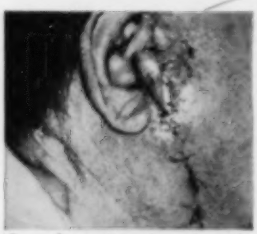
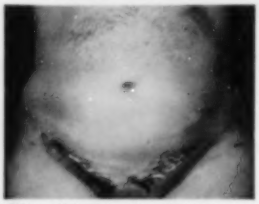
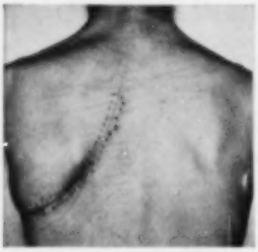


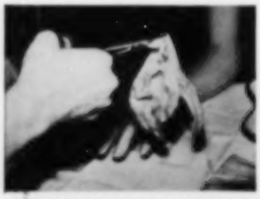
Face laceration dressed with Aeroplast healed in four days.[2]



Bilateral inguinal hernia incisions protected by Aeroplast 4th post-operative day.[1]



Thoracotomy wound completely healed 13 days after operation and dressing with Aeroplast.[1]



Aeroplast dressing is peeled off like a glove 12 days after 2nd degree burn.[2]

Sprayed directly onto the lesion from an aerosol "bomb," Aeroplast forms a protective plastic film dressing over any body contour. Aseptic lesions remain sterile as long as the dressings are intact. Aeroplast dressings are impermeable to bacteria. To remove, Aeroplast is simply peeled off.

Rigler and Adams[1] dressed 110 operative wounds (including thoracotomies, laparotomies, inguinal hernias and miscellaneous lesions) with Aeroplast. "A single application sufficed in all but fifteen cases. No instances of systemic or clear-cut reactions were observed. Satisfactory results, with no evidence of erythema, infection, or necrosis were obtained in the majority of cases."

In 39 miscellaneous wounds dressed with Aeroplast (including appendectomies, open reduction of fractures, skin graft donor sites, lacerations, excoriation), Choy[2] reports infection in only one case, which promptly cleared with redressing, and uneventful healing in all others.

1. Rigler, S. P. and Adams, W. E.: Experience with a new sprayable plastic as a dressing for operative wounds, Surg. 36:792 (Oct.) 1954. (University of Chicago Clinics, Chicago, Surgical Service).
2. Choy, D. S. J.: Clinical trials of a new plastic dressing for burns and surgical wounds, Arch. Surg. 68:33 (Jan.) 1954. (Bellevue Hospital, New York, Third Surgical Division—Dr. John Mulholland, chief).

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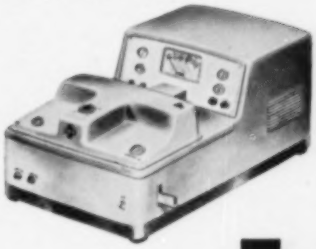

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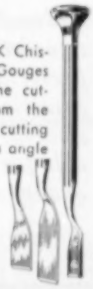

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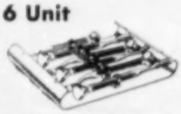

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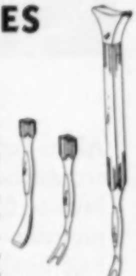

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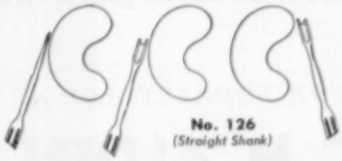

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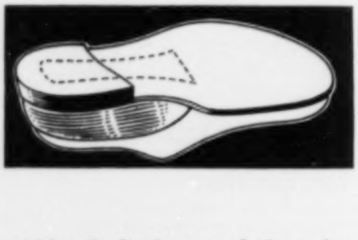

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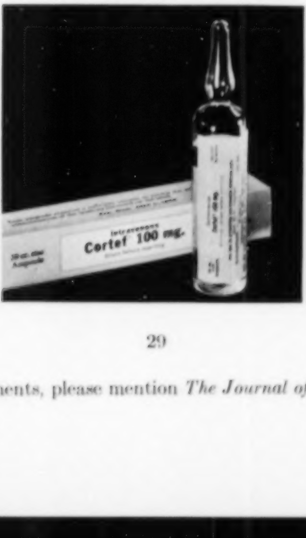

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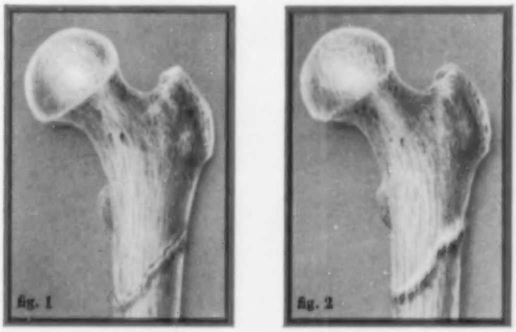

Femur, fracture, oblique, upper third.

Healing of fractures is often delayed in the aging patient because impaired osteoblastic activity due to declining sex hormone function causes the bone matrix to atrophy. Note incomplete union of fracture (fig. 1) in patient with postmenopausal osteoporosis, in contrast with normal union (fig. 2) when a proper ratio exists between osteoblastic and osteoclastic activity.

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*Reifenstein, E. C., Jr., in Harrison, T. R.: Principles of Internal Medicine, Philadelphia, The Blakiston Company, 1950, p. 655.

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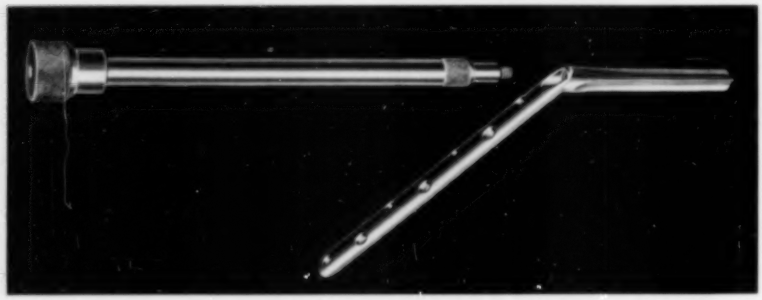

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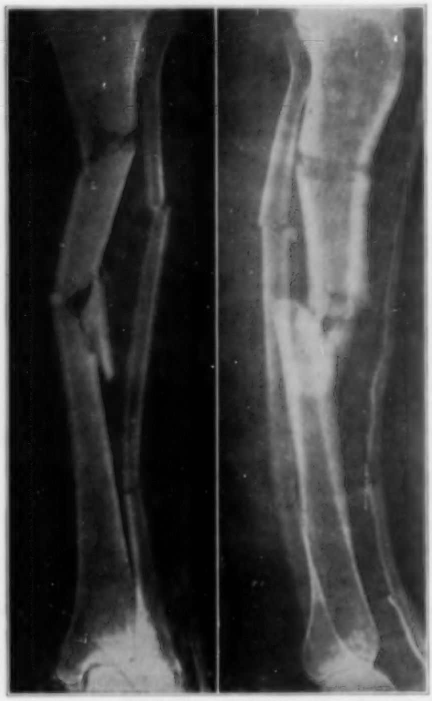

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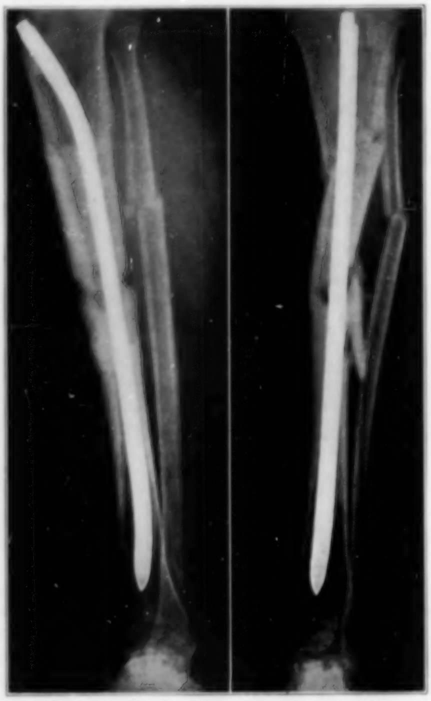

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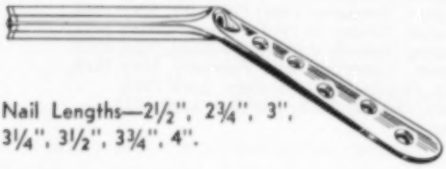

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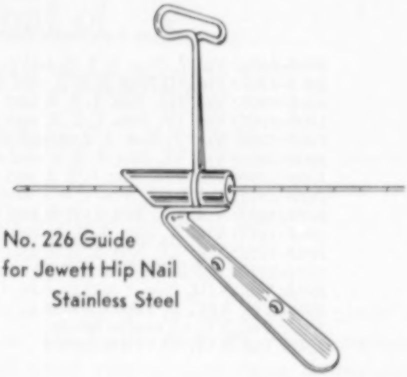

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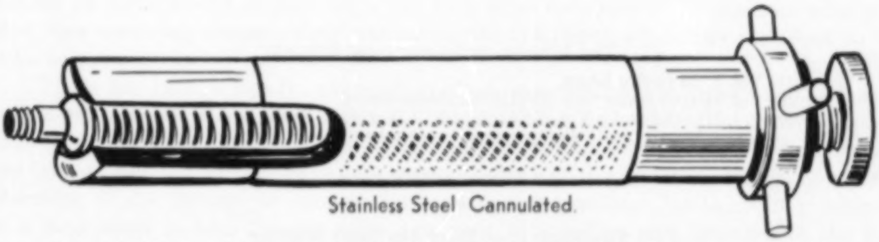

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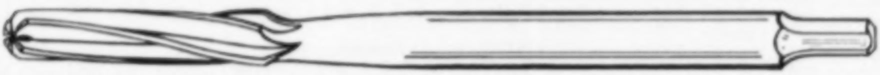

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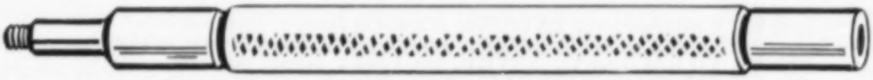

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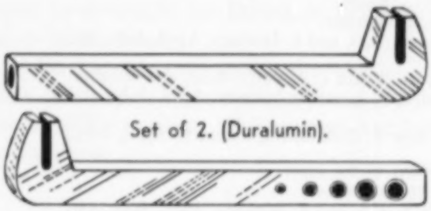

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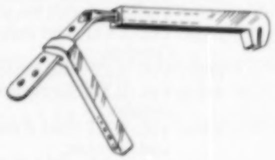

Illustration shows one of many uses of plate bending irons.

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VOL. 36-A, NO. 6 DECEMBER 1954

The Journal of
Bone and Joint Surgery
American Volume

THE MANAGEMENT OF THE TUBERCULOUS HIP JOINT *

BY PROF. WALTER MERCER, EDINBURGH, SCOTLAND

Many of us must remember, almost with horror, the end results of tuberculosis of the hip in the early days of our surgical practice. The results were often characterized by terrible deformity, but, with the high over-all death rate in those days, it was considered an achievement to save life, even with gross deformity. The means available at that time were very meager; there was no specific treatment which had any effect on the tuberculous organism.

There has been a steady, although gradual, improvement in treatment, and more satisfactory results have been obtained. The crowning achievement in treating tuberculosis has been the introduction of antibiotics; inevitably our approach to the problem has been altered, for we now have a far greater control of this disease. Two changes in the character of the disease—at least in Scotland—are interesting: Joints are now affected at a later stage in life. Twenty years ago most tuberculous hips occurred in the first five years of life, but now, with the proper feeding of infants, joint involvement occurs five to ten years later in the next age decade. This is due partly to the gradual replacement of raw, or unprocessed, milk for infant-feeding by dried, bottled, or pasteurized milk which protects the infant in the earlier years of life from primary infection. Unfortunately, in the next age group, that is, in young school children, the introduction of the milk-in-schools scheme has resulted in the exposure of a considerable number of school children, who otherwise would have escaped infection, to the risks of drinking raw milk. However, the vaccination of children in this age group with Bacillus Calmette-Guérin will have a definite effect in reducing the incidence of joint tuberculosis, as will also such factors as early hospitalization of all patients with "open" pulmonary disease and the improvement in economic conditions, in housing, and in nutrition, all of which are now taking place in Scotland.

Bovine infection used to be four to five times more common in skeletal tuberculosis than the human type, but a reversal of this has now taken place and, in a recent investigation of 950 patients, 26.3 per cent. had bovine tuberculosis and 73.7 per cent. had human tuberculosis.

DIAGNOSIS

One of the chief difficulties now in patients with hip-joint disease, as indeed it has always been, is the accurate diagnosis of the early case. Frequently, we see a patient with the clinical signs of arthritis of the hip or, as it is called, transient arthritis (an "observation hip"), with a limp, limitation of movement by muscle spasm, and perhaps pain. The history is usually of a few days' duration, with little evidence of a systemic illness—

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* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 8, 1954.

although there may be a mild pyrexia—and a "reported normal" roentgenographic appearance of the joint.

Accurate diagnosis in such a patient is so important that every possible means of diagnosis must be employed, as the prognosis has been so immeasurably improved by the introduction of chemotherapy. We now know that there is a reasonable chance of obtaining a mobile joint if the disease is recognized in its early synovial stage; early proof of the lesion is, therefore, imperative.

It is obvious, however, that the diagnosis of a transitory arthritis from a tuberculous lesion is most difficult. Historically and symptomatically, these are often identical and remain so for weeks during the early treatment, which is usually by means of traction for the relief of pain and resulting spasm.

After the history (family and personal) has been taken and the clinical examination, which may be helpful, has been made, the erythrocyte-sedimentation rate is estimated, as is the white blood cell count. These are not specific. The Mantoux test is only of value if it is negative on repetition. Roentgenograms are made of both hips and the chest. We rarely see tuberculosis of the hip so early that there is no roentgenographic abnormality. There is usually, in the early case, a little atrophy of the affected side seen on comparison with the unaffected side. If there is not the slightest alteration in density, we are chary of making the diagnosis of tuberculosis, although if we find a typical Ghon lesion in the lung, or enlarged paratracheal glands, we rather expect the condition in the hip to be tuberculosis.

If there is bone atrophy, a biopsy of the deep inguinal glands is carried out; from the point of view of diagnosis, this is more important than an arthrotomy, since the bacilli are filtered to the glands and are more likely to be found. If the biopsy specimens from the glands reveal bacilli, the diagnosis is settled; but arthrotomy may still be considered if the diagnosis remains in doubt. In the past, a provisional diagnosis was accepted as an indication for hospital treatment, and the patient's subsequent course either proved or disproved the tuberculous nature of the disease. Now that there is a good prospect of obtaining a mobile joint, if the disease is diagnosed at an early stage, early proof of the lesion is imperative. Doubtful cases are not now admitted to hospital for long periods of observation before a definite diagnosis is made. We exert ourselves to reach an early diagnosis. Synovial biopsy is being done more and more often, and, with antibiotics, the biopsy wound heals satisfactorily. As McKenzie has aptly said, the old method of *wait and see* has given way to a policy of *look and see*.

Arthrotomy has an even more important purpose than that of proving the presence of tuberculosis, for it relieves the tension on the joint and the effects of tension on the blood supply of the joint.

At the periphery of the joint, where the synovial membrane is reflected from the cartilage, is the circulus articuli vasculosus, of which the end arteries are end arteries in the sense that they do not form anastomoses. Local obliterating endarteritis is one of the main features of the pathology of tuberculosis; it follows, therefore, that a local ischaemia is a common and early finding in skeletal tuberculosis. Once ischaemia has occurred, antibiotic drugs can reach the part only with difficulty unless the way has been opened for them by some surgical procedure. One such procedure is synovectomy; this is what is done now at biopsy. The synovial membrane regenerates rapidly after removal, and, therefore, synovectomy—partial though it may be in some cases—affords an opportunity for a healthy membrane to develop, along with fresh blood vessels which will bring the antibiotic into the diseased area.

We talk glibly of doing a biopsy, of culture, and of guinea-pig inoculation, as though these gave an absolute diagnosis; but this is not always so, unfortunately. I believe that there are a few cases in which, because of the absence of confirmatory evidence of this nature, we have to rely on a summation of all facts which we can interpret by using our clinical judgment based upon experience—our surgical acumen.

TREATMENT

In any consideration of the treatment of the tuberculous hip joint, it is obvious that chemotherapy has allowed us to return to the more radical methods of local attack, some of which, in years gone by, were disappointing because they were so often followed by sinus formation and dissemination of the disease. We must, however, always bear in mind that tuberculosis is a general disease and that the joint lesion is but a metastatic manifestation of it. Thus the involvement of the deeply situated glands, inaccessible, insidious, and in issue far more dangerous than the lesion itself, should ever be in our minds. This makes the sanatorium regimen still imperative.

Children responded well to this regimen, with healing of the adenitis, as well as of the concomitant bone lesion, but this took a long time. Many of our patients required sanatorium treatment for five years or more in the days before the introduction of chemotherapy. This period of prolonged immobilization led to many complications, such as premature fusion of the epiphyses, with shortening of the extremities and resultant stunting, both physical and mental, as well as other forms of morbidity.

It was also noted that adults did not respond so well and often had re-activation of the glandular focus with a substantial late mortality from associated lesions.

What a change now! Streptomycin and associated drugs have allowed us to make a direct surgical attack on the joint; in patients seen early, therefore, we may hope for a mobile joint, and in patients seen late, a shorter period of immobilization, an earlier and quicker fusion, and fewer, if any, complications.

There is no doubt that the best results are now obtained by the use of streptomycin in combination with other drugs and surgery. These do not supersede a sanatorium regimen, but merely reduce the time in which it is necessary.

I think we, in Scotland, are perhaps more optimistic than you, in America, are about the future of skeletal tuberculosis now that we have antibiotics. Streptomycin, augmented by para-aminosalicylic acid, or substituted for by isonicotinic acid hydrazide (isoniazid), gives the orthopaedic surgeon a far greater control of the course of the disease at any stage; hence, we must consider how our approach should be changed to utilize to the full the benefits of these drugs. Even at this early phase of the history of these chemotherapeutic agents, it is worth while to consider one or two of their properties before we accept them complacently as being the final and definitive answer.

Resistance, or drugfastness, to these three drugs occurs early if they are administered separately. Para-aminosalicylic acid decreases the number of streptomycin-resistant strains, especially if the dosage is twenty grams of sodium para-aminosalicylate daily [4], with a combination of isoniazid and streptomycin, one gram twice weekly. There has been no report of resistance to either drug [2]. We are as yet unable to define whether resistance is due to a mutation or to an adaptation resulting from a selection of resistant strains.[1] Therefore, we can only partially prevent the occurrence of this complication to treatment by certain combinations of drugs, but even so resistant strains are being steadily built up.

The antibacterial factor of efficiency of these drugs, unfortunately, is not comparable with that of penicillin in the treatment of pyogenic osteomyelitis, this being due to the pathological nature of the tuberculous infection. Jensen, Bindslev, and Holm have described the intracellular localization of living tubercle bacilli in the mononuclear or epithelioid cells. Therefore, the chemotherapeutic agent must be able to penetrate these cells in order to kill the tubercle bacillus, and so far only isoniazid has been shown to be capable of entering macrophages or phagocytes.[7] Continuing the study of this property of penetrability, or lack of it, Ebert and Barclay, using the transparent-chamber technique in rabbits, showed how the initial, and most temporary, wide dilatation of vessels around a tubercle was quickly closed by thrombosis, with resultant stasis of blood flow around the now necrotic area.

Bosworth, Wright, and Fielding, in 1952, have described how, apart from the bacteriostatic property of isoniazid, this drug produces a capillary dilatation, with cutaneous flushing. Capillary dilatation may increase the vascularity around the diseased area, but it is unlikely to assist in the penetration of the chemotherapeutic agent because of the thrombotic nature of the change in the capillaries.

Therefore, it is only in the most early stages of the pathology of this lesion that our agents are efficient, and it is only too well known how comparatively late we see and diagnose a tuberculous focus in bone around the hip joint. Because of this, it is now one of the primary objectives of the surgeon to give access to these chemotherapeutic agents to all diseased areas as early as possible.

On first giving streptomycin to a patient with a proved tuberculous infection of the hip, it is usual to see an initial systemic improvement, with relief of symptoms and most signs, but even though chemotherapy is continued, there is a definite regression and slowing up in the improvement, this being due to the appearance of some degree of resistance formation. Although surgery should probably have been carried out earlier, it can still be done, as continuing treatment with streptomycin will prevent any further dissemination or sinus formation due to secondary organisms.

The following combinations advocated by Crofton of Edinburgh are satisfactory in the treatment of the sort of case we are discussing:

1. Streptomycin sulphate, one gram daily, with sodium para-aminosalicylate, five grams four times a day; (In the United States the drug is usually expressed in terms of the *acid*, whereas in Great Britain it is usually expressed in terms of sodium para-aminosalicylate; the twenty-gram dose of sodium para-aminosalicylate, I suggest, corresponds roughly to about fifteen grams of para-aminosalicylic acid. This difference in the expression of dosage has caused a great deal of confusion.)

2. Streptomycin sulphate, one gram daily, combined with isoniazid, 100 milligrams twice a day;

3. Isoniazid, 100 milligrams twice a day, combined with sodium para-aminosalicylate, five grams four times a day.

With any of these combinations, the incidence of drug resistance should be exceedingly low. The existence of bone or joint tuberculosis always indicates that there has been a hematogenous dissemination of the disease, and I am as concerned in trying to knock out other cryptic foci of tubercle bacilli as to deal with the more obvious lesion. Both for the immediate effect on the hip lesion and the effect on the cryptic lesions, I am strongly in favor of really prolonged chemotherapy. I have thought that a year is a reasonable minimum period of time in which to continue with the treatment, but I would ordinarily prefer to continue chemotherapy for at least three months after it has been decided that the local lesion is quiescent and well under control. After the first six months or so, if combinations involving streptomycin have been used, I would be happy to switch to a combination of isoniazid and sodium para-aminosalicylate, in order to save the patient so many injections. Under no circumstances should any of these drugs be used alone. I believe that treatment with streptomycin twice a week combined with isoniazid daily has been used fairly extensively in the United States, but the Medical Research Council in Great Britain has shown that treatment with such a combination carries with it a considerable risk of the development of isoniazid resistance.

The hip joint may be affected with tuberculosis in three ways: an extra-articular focus, synovial disease, and an intra-articular lesion with destruction of the cartilage. I would like to state how we treat these lesions:

1. *Extra-Articular Focus*

Even before the days of streptomycin, we excised an extra-articular focus, with some measure of success, when it was accessible. It is much safer to do so now, and it should be carried out, of course, before the adjacent joint becomes involved. After antibiotics have been administered, the excision is carried out. It is a good practice to fill the cavity, after a thorough removal of all diseased bone, with cancellous-bone chips and to use streptomycin and penicillin powder locally. One can, with confidence, look forward to a complete reconstitution of the bone and, of course, a mobile hip.

2. *Synovial Disease*

In synovial disease, with a tense full joint and with the synovial membrane and capsule ballooned out due to an effusion, there is every prospect of obtaining a mobile joint if the streptomycin and other drugs can reach it in sufficient concentration and if, of course, the joint surfaces are undamaged. The tuberculous exudate does not contain proteolytic enzymes, such as those seen in the exudate of pyogenic infection; the cartilage tends, therefore, to persist until a later stage when it is covered by the tuberculous pannus of unhealthy granulation tissue. Early diagnosis and decompression are essential in order to save the joint, and, therefore, biopsy is justified, apart from diagnosis, to relieve tension and to allow the penetration of the chemotherapeutic agent. We must, therefore, in carrying this out, remove as much of the diseased synovial membrane as possible, together with part of the capsule. This will inevitably turn the tide in the patient's favor and will lead to a higher percentage of mobile hips. Synovial membrane regenerates rapidly. After removal of the diseased synovial membrane at operation, fresh normal synovial tissues, carrying young blood vessels through which the antibiotics can circulate freely, will form. The only form of immobilization necessary during this treatment is by skin traction. Nutrition of the limb must be maintained.

3. *The Intra-Articular Lesion*

Intact articular cartilage: Up to a few years ago, even the intra-articular lesion was considered to be cured only when there was bony fusion, but it is recognized that there are still some cases in which, although the lesion is intra-articular, most of the articular cartilage is still intact. Therefore, there is still the possibility of obtaining a mobile hip, at least for many years. The diseased focus in Babcock's triangle or in the acetabular region is approached and is thoroughly eradicated, the area being packed with cancellous-bone chips. Penicillin and streptomycin powder are used locally. It is necessary to immobilize the joint in plaster for a few weeks (in the case of femoral foci) or by fairly heavy traction (in the case of acetabular foci). A certain proportion of hips will still heal by fusion or may require arthrodesis later, but it is remarkable how many will have mobility at the end of treatment. A long period of follow-up is necessary in order to be able to tell whether the mobility and cure is going to be permanent. Although some patients will show extension of the osseous disease process and may require arthrodesis at a later stage (the price of delay in applying definitive treatment), we may gain a mobile hip and all of its benefits in many patients. If the chemotherapy is continued long enough, re-activation, or flare-up, of the tuberculosis is less likely to occur.

Damaged articular cartilage: If the patient comes under treatment at such a late stage that the articular cartilages are obviously irretrievably damaged, then bony fusion is necessary. One now need only to wait until the patient's general resistance has been built up in order to overcome the general toxaemia of the bacillary invasion; this is aided greatly by the use of chemotherapy. I invariably perform a Brittain arthrodesis. I often do this operation now, however, by means of an open approach from the posterior aspect; this allows identification of the sciatic nerve, open inspection of the joint, with relief of intra-articular tension, and removal of necrotic debris. Brittain's method is infallible in securing union, due no doubt to a compressing force, rather than a distracting one as seen in the iliac-trochanteric operation.

A further consideration is the presence of a tuberculous abscess. This should be removed as soon as possible, usually by aspiration. This may not, however, be possible, and it may be necessary to drain the abscess by incision. Just as in the treatment of acute osteomyelitis, it is the tension in the bone rather than the infection that causes thrombosis of the vessels and the formation of a sequestrum, so in tuberculosis pus under tension causes delay in healing if not spread of the infection.

Every effort should be made to cause sinuses to heal and to prevent secondary infection. This can usually be achieved by using antibiotics, locally and generally. Even long-standing sinuses will now heal in a few months; surgery may be needed if the walls of the sinus tract are very thick, or if there is an associated sequestrum of bone.

CONCLUSIONS

It is obvious to us all that the handling of infective granulomatous diseases lies in the realms of sociology and preventive medicine. The day of this is still far distant, and it is our duty with present-day knowledge and experience to consider the future of this lesion.

Chemotherapy for the *Mycobacterium tuberculosis* has been long enough in general use for us to accept it as the most useful adjunct to surgery, the principles of which, in turn, must be modified and advanced so that its properties are fully utilized in the treatment of this incapacitating condition. Antibiotics may be expected to shorten the course of the disease. Rigid immobilization for a long time is probably no longer essential, and one hopes that the unfortunate effects of immobilization, such as renal calculi, osteoporosis, and premature epiphyseal closure, leading to a woefully short extremity, will also become things of the past. I fully expect that the bacteriologist and the biochemist will give us other chemotherapeutic agents of greater bacteriostatic and penetrating properties, and that our surgical treatment will correspondingly advance, resulting in more mobile hips. There will, however, often be some derangement in the usual architecture of the surfaces of this weight-bearing joint, because most tuberculous lesions heal by fibrous tissue or recalcification, without regeneration of the original tissues. The complication of osteo-arthritis is thus likely to arise with its own peculiar difficulties in treatment, and arthroplasties will have to be carried out at a later stage of life. Most of us will be ready and pleased to treat this complication when it arises, after the patient has had for several years the use of a functioning hip joint.

To achieve bony ankylosis of a tuberculous hip joint (particularly in the advanced intra-osseous type of lesion) must still be our aim and the method of choice because of its long proved efficacy. However, I do suggest that now, more than ever, we must strive for early diagnosis of the lesion by biopsy (with its concomitant decompression of the tuberculous lesion of the hip joint) so that the patient is left with a functioning and mobile hip.

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ARTHRODESIS OF THE HIP IN WIDE ABDUCTION *

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Arthrodesis of the hip joint is often difficult to obtain, even under the most favorable conditions. When fusion of this joint is indicated, the surgeon has several methods at his disposal. If the head and neck of the femur are viable, a combined intra-articular and extra-articular procedure is probably the method of choice. In those patients who have suffered destruction of the femoral head and neck following disease or previous surgery, the ordinary methods of arthrodesis often fail.

In 1931 one of us (L. C. A.) was co-author of an article which described an intra-articular method of performing arthrodesis of the hip in children who had massive destruction of the joint due to tuberculosis or pyogenic infection [2]. At that time surgical fusion of the hip joint had been well established as sound treatment, and several methods of obtaining fusion had been advanced by various surgeons. At the Shriners' Hospital in St. Louis many neglected children were seen in whom deformity and joint destruction were severe. The frequent failure to obtain bony fusion in these patients by the then accepted methods of arthrodesis led to the development of the treatment which we called "arthrodesis of the hip in wide abduction".

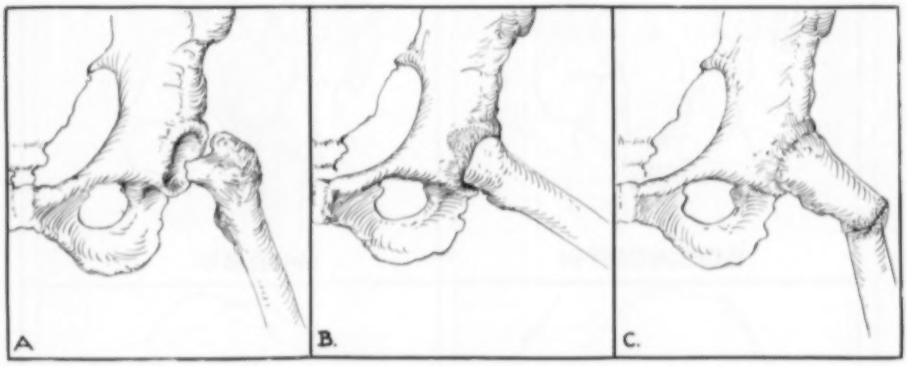

FIG. 1

Three stages in arthrodesis of the hip in wide abduction.

A: Preoperative position, with the greater trochanter opposite the acetabulum.

B: Placement of the greater trochanter in the acetabulum.

C: Subtrochanteric osteotomy.

EARLY METHOD

The method as originally described was done in three stages: (1) correction of the deformity, (2) arthrodesis of the hip in wide abduction, and (3) reduction of the widely abducted position by subtrochanteric osteotomy (Fig. 1). The usual deformities of flexion, adduction, and shortening were corrected by appropriate traction as the extremity was gradually brought to a position of wide abduction. In some cases, in which the greater trochanter was fixed to the ilium, a preliminary excision of scar tissue was done before traction was applied. When the greater trochanter was adjacent to the acetabulum, a

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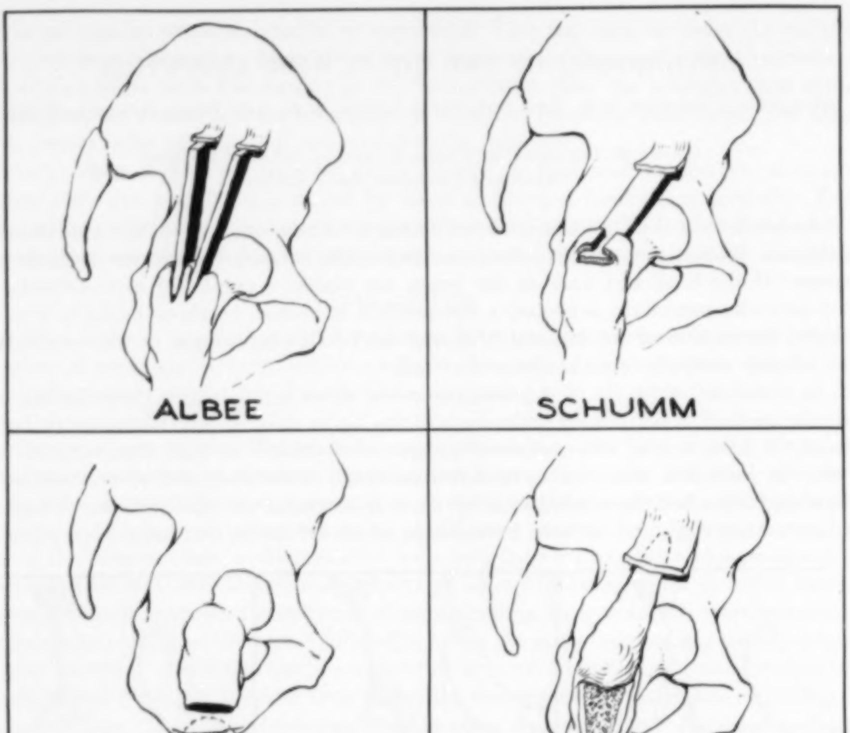
* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 7, 1954.



ALBEE

SCHUMM

BOSWORTH

HIBBS

CHANDLER

KEY

Fig. 2-A

Figs. 2-A and 2-B: Review of the principal methods of intra-articular and extra-articular arthrodesis of the hip, with drawings adapted from the authors' original publications.

Smith-Petersen incision was used to expose the acetabulum and the upper portion of the femoral shaft. The acetabulum was thoroughly debrided, and cortical bone was removed from the upper and inner surfaces. After the excision of any remaining parts of the femoral

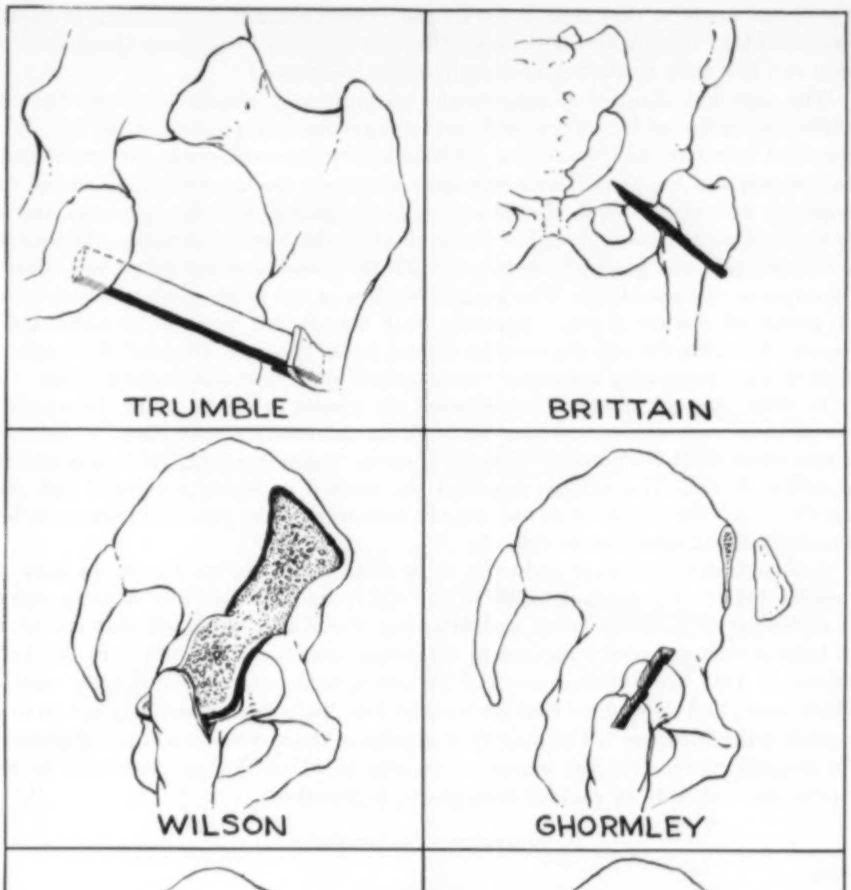

TRUMBLE
BRITTAIN
WILSON
GHORMLEY
HENDERSON
SPEED
TOM RAUBENHEIMER

FIG. 2-B

neck, the cortical bone was also removed from all surfaces of the greater trochanter and from the adjacent shaft of the femur. With the extremity abducted, the denuded surface of the greater trochanter was brought into intimate contact with that of the acetabulum. The angle of abduction which gave optimal contact varied from 30 to 90 degrees. No attempt was made at that time to secure the correct position for function. It should be emphasized that the sole aim of the operation was to secure bony union through accurate fitting and extensive apposition of cancellous-bone surfaces.

The cast was changed at appropriate intervals and, usually in about five to six months, was removed for clinical and roentgenographic examination of the hip. If bony fusion had been obtained, transverse subtrochanteric osteotomy was performed and the bivalved cast was reapplied. Two weeks after osteotomy the hip was examined and roentgenograms were again made. If sufficient callus formation was demonstrated, the spica was removed and adhesive traction was applied to the lower extremities. Abduction on the affected side was gradually reduced, while the position of the pelvis was controlled by traction on the sound side. This gradual bending of the callus required about ten days and permitted control of the fragments until the desired position of abduction was obtained, following the method used by Adams in the Shriners' Hospital, St. Louis. This simple method of bending the callus was described by Abbott and Jostes in 1926.

In 1931, Abbott and Fischer recorded the results in eleven cases. In two of the patients there were sinuses, and bony fusion of the joint did not take place. In the remaining nine cases, solid bony fusion occurred in seven; union was doubtful in one and there was failure in one. The authors regarded the method as highly successful and one of them (L. C. A.) has continued to use it in the past twenty-four years for patients in whom arthrodesis would otherwise be difficult.

Although this method of abduction arthrodesis is used in our Clinic, we have come to realize that it is a method which is not widely known. This was recently called to our attention by Kirkaldy-Willis and Mbuthia. These authors stated that one of them had been introduced to the method of abduction arthrodesis of the hip in the London Hospital in 1947 by Watson-Jones and Osmond-Clarke, who said that they used it in difficult cases, and they added that the method was "little known and may not have been recorded in the literature". The paucity of reports on the abduction method of arthrodesis is in striking contrast to the numerous articles in which the intra-articular or extra-articular method, with or without bone grafts, is described.

COMPARISON OF METHODS

Review

Extra-articular arthrodesis for tuberculosis of the hip has long been an accepted method of treatment. Albee first described this method in 1919, and in 1929 published a review of thirty-one cases. He wedged tibial grafts between the greater trochanter and the ilium. Schumm modified this technique by placing tibial grafts beneath osteoperiosteal grafts from the ilium and the trochanter. Trumble in 1932 advocated ischiofemoral arthrodesis and placed a tibial graft between the upper portion of the femoral shaft and the ischium through a posterior approach. In 1941 Brittain also advocated ischiofemoral arthrodesis. He performed subtrochanteric osteotomy and shifted the femoral shaft medially by interposing a tibial graft between the fragments. A year later Bosworth reported a method in which he excised the proximal end of the femur and transplanted the shaft beneath the ischium in performing ischiofemoral arthrodesis.

Intra-articular arthrodesis gained favor following Hibbs' report of his method in 1926. He used the greater trochanter as a graft which he reversed and wedged into the ilium. The following year Wilson described a method in which an iliac flap was turned down and inserted into a cleft made in the trochanter. In 1931 Ghormley advised using the iliac crest as a graft which could be slotted into the ilium, femoral neck, and trochanter. Chandler in 1933 reported a method whereby a large graft was removed from the upper part of the shaft and trochanter, reversed, and wedged beneath an iliac flap. In addition, cancellous bone was packed about the denuded upper surface of the head and neck of the femur.

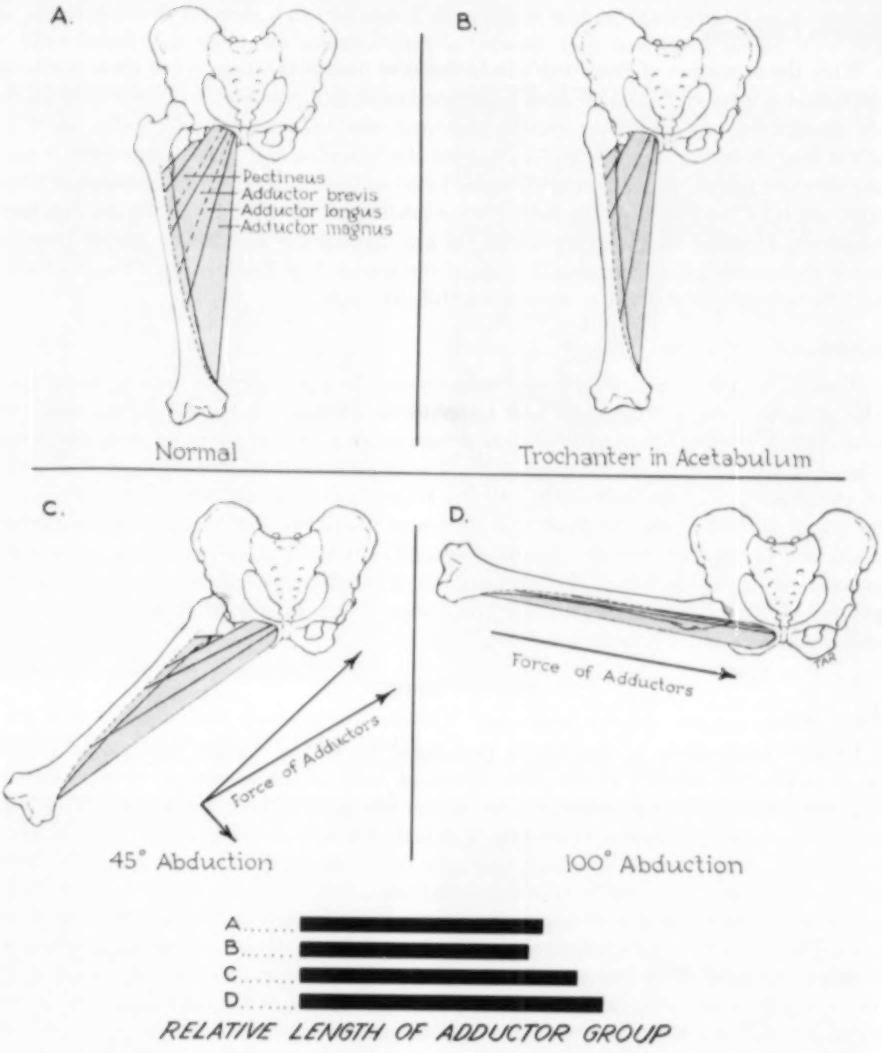

A.
B.
Pectineus
Adductor brevis
Adductor longus
Adductor magnus
Normal
Trochanter in Acetabulum
C.
D.
Force of Adductors
Force of Adductors
45° Abduction
100° Abduction
A.......
B.......
C.......
D.......
RELATIVE LENGTH OF ADDUCTOR GROUP

Fig. 3

Drawings showing the relationship between the position of the femur and the passive tension developed in the adductor muscles.

A: With the femur in neutral position, the adductor muscles are at rest length and exert no passive tension.

B, C, and *D:* The head and neck of the femur have been excised and the greater trochanter has been placed in the acetabulum. With increasing abduction, the adductor muscles exceed rest length and passive tension is developed. The arrows indicate the direction of this impacting force.

Key in 1926 was one of the first to advise removal of the involved femoral head. He secured fusion by inserting the trochanter under an iliac flap and obtained reinforcement by means of tibial osteoperiosteal grafts. Actual removal of articular cartilage and joint debris was reported by Henderson in 1933. An additional iliotrochanteric graft removed from the outer table of the ilium was used. Speed, in 1937, described an intramedullary tibial graft which traversed the femoral neck. He used this in addition to the Wilson-type graft.

Evaluative Comments

With the exception of Bosworth's ischiofemoral transplantation, all of these methods make use of a bone graft. All of them place the femur in a position of optimum function, while attempting to secure bony fusion. The time required for revascularization of tibial grafts is long, however, and during this period the ischiofemoral grafts frequently break. Iliotrochanteric grafts depend for their stability on an intact joint; with increasing absorption of the head and neck of the femur, these grafts may displace and fibrous union may then result. Most of the methods reviewed are inadequate in cases in which there is massive destruction of the head and neck of the femur. For these reasons we have continued to employ the abduction method for difficult cases.

The Abduction Principle

Abduction arthrodesis provides intimate contact between the raw cancellous surfaces of the denuded greater trochanter and acetabulum. Circulation to the apposed surfaces is excellent. A constant compressive force is maintained by the adductor muscles. When the femur is abducted about 100 degrees, the line of pull of the adductor muscles coincides with the direction of the shaft (Fig. 3, *D*). In abduction of 45 degrees the maximum force is still exerted along the shaft. As the femur is abducted, tension in the adductors is developed by passive stretch. This passive tension is transmitted axially to impact the femur against the acetabulum, thereby providing excellent contact and immobilization. Tightness of the adductors, which is usually seen in hip disease of long standing, thus materially aids in immobilizing the fusion site.

PRESENT METHOD

Indications

Usually arthrodesis of the hip is performed to halt a disease process, to relieve pain, or to provide stability in the joint. Although most of our operations were performed on patients who had massive destruction of the hip joint following tuberculosis or pyogenic infection, we now realize that abduction arthrodesis is also an excellent procedure in patients with destruction of the head and neck of the femur from other causes. We have used this method in non-union of the femoral neck followed by aseptic necrosis of the head; in cup arthroplasty with sepsis; in a long-standing, irreducible dislocation of the hip in a patient with tension athetosis; and in Legg-Perthes disease when another method had failed. Some of these cases are too recent for end-result evaluation. However, in all of them fusion is proceeding satisfactorily. Kirkaldy-Willis and Mbuthia are in accord with the indications mentioned for the use of abduction arthrodesis.

It has often been said that, once the surgeon has performed a femoral replacement arthroplasty, he has burned his bridges behind him in the event that the prosthesis fails. We do not believe that this is the case, because the abduction method of arthrodesis is ideally suited for obtaining fusion in this type of case. In cases of degenerative joint disease, in which avascularity of the femoral head makes fusion difficult, this method may also prove to be the most satisfactory. At a later date we plan to publish the results of further experience with this method of arthrodesis of the hip.

Modifications in Early Method

Several modifications have been made in the method as now practised. Rarely is it necessary to correct the deformity by traction before surgery, because neglected cases are now seldom seen. As has been mentioned, some degree of adductor tightness is to be desired. We have also found that osteotomy can be safely performed much earlier than had been previously thought. In the paper by Kirkaldy-Willis and Mbuthia, it was advised that osteotomy be performed three to four weeks following the fusion operation. Naturally this period depends somewhat on the age of the patient and on the initial disease process. We have found that the most suitable time is between four and eight weeks. The final

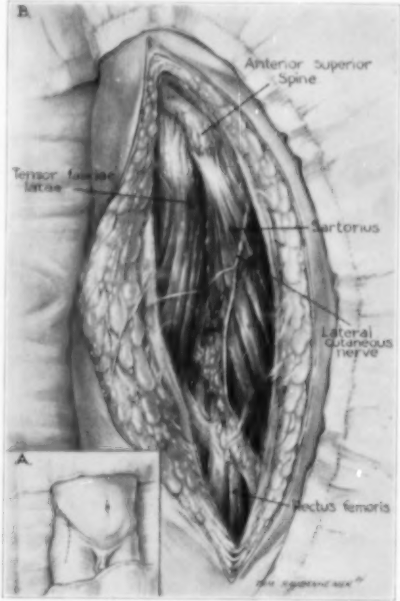

B
Anterior superior Spine
Tensor fasciae latae
Sartorius
Lateral cutaneous nerve
Rectus femoris
A

Fig. 4

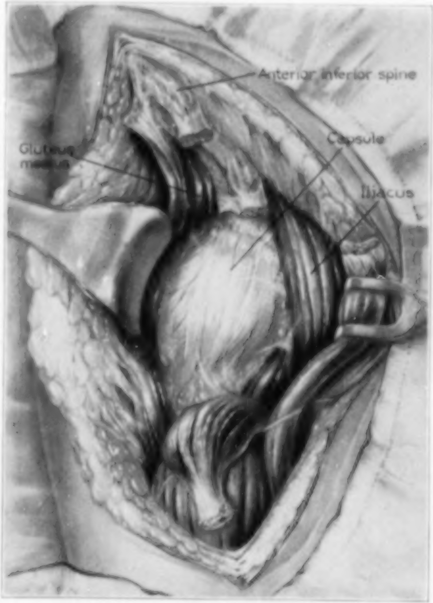

Anterior inferior spine
Gluteus medius
Capsule
Iliacus

Fig. 5

Fig. 4: *A:* The inset shows the line of skin incision. *B:* The drawing shows the skin and subcutaneous tissues reflected to show the underlying structures.

Fig. 5: The capsule of the hip joint is exposed after detachment of the sartorius and rectus femoris.

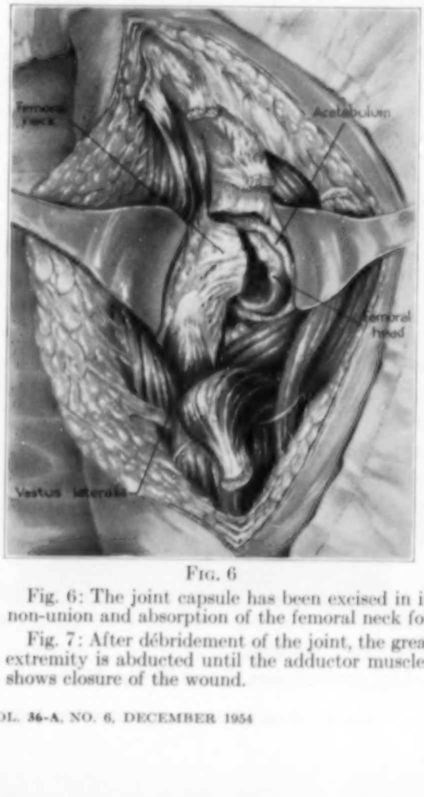

Femoral neck
Acetabulum
Femoral head
Vastus lateralis

Fig. 6

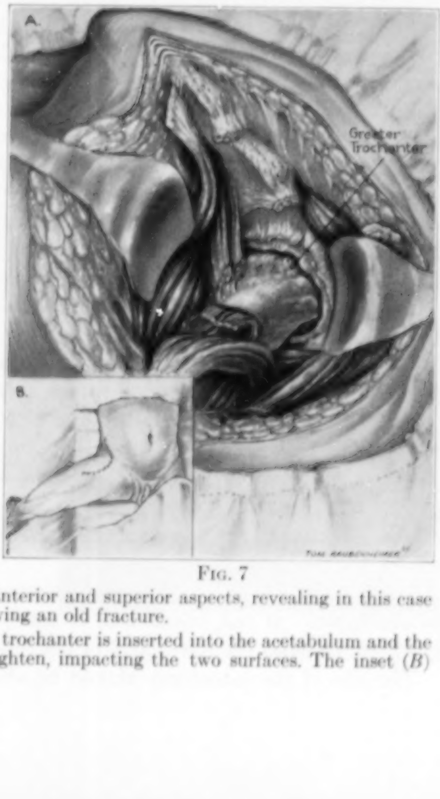

A
Greater Trochanter
B.

Fig. 7

Fig. 6: The joint capsule has been excised in its anterior and superior aspects, revealing in this case non-union and absorption of the femoral neck following an old fracture.

Fig. 7: After débridement of the joint, the greater trochanter is inserted into the acetabulum and the extremity is abducted until the adductor muscles tighten, impacting the two surfaces. The inset (*B*) shows closure of the wound.

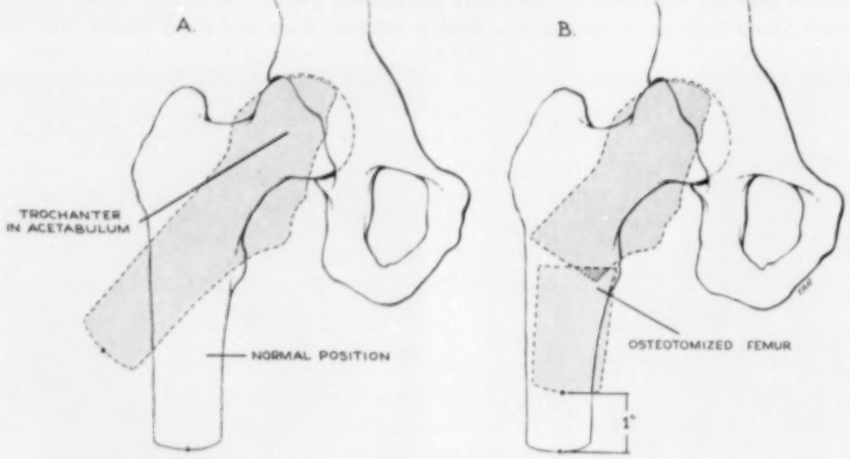


Fig. 8

Drawings made from the roentgenogram of a normal hip to show the actual amount of femoral shortening which would be obtained after, *A*, placement of the greater trochanter in the acetabulum and, *B*, subsequent subtrochanteric osteotomy.

decision depends on clinical evidence of early consolidation of the fusion site. The additional hospitalization required by the method of gradually bending the callus no longer seems justifiable, since we have found that final positioning at the time of osteotomy is usually satisfactory.

Operative Procedure

With the patient supine, a routine Smith-Petersen incision is made to gain access to the hip joint (Figs. 4 and 5). The capsule of the joint is excised in its anterior and superior aspects in order to expose the intracapsular structures (Fig. 6). In the patient with tuberculosis or sepsis a thorough débridement of the joint is carried out, which includes removal of all acetabular articular cartilage. The remaining portion of the femoral neck is resected at its base, and the gluteal tendons are stripped off the greater trochanter and the adjacent part of the femoral shaft. With a curved gouge, the subchondral bone in the acetabulum is removed from the superior, anterior, and posterior surfaces, until healthy cancellous bone is seen exposed. The roof of the acetabulum is deepened slightly to permit better seating of the greater trochanter. The greater trochanter is then denuded of cortical bone and is placed in the acetabulum (Fig. 7). With the foot in lateral rotation of about 5 to 10 degrees, the thigh is flexed about 35 degrees and is slowly abducted until the adductor muscles tighten. The amount of abduction obtained will depend on the tightness of the adductor muscles before operation. Usually 45 degrees are necessary before the trochanter becomes impacted in the acetabulum. It should fit as snugly as possible. Any remaining space may be packed with cancellous-bone chips—removed from the adjacent ilium—to prevent ingrowth of fibrous tissue. The authors use a sterile instrument stand with an adapted gutter attachment to hold the extremity in position while the wound is being closed. A bilateral hip spica cast is applied, extending to the toes on the involved side and to the knee on the uninvolved side. Routine roentgenograms are made to check the position in the plaster.

Six to eight weeks later the cast is removed and the hip is checked clinically and by roentgenograms. If the fusion site is solid, a transverse subtrochanteric osteotomy is carried out through the lower arm of the Smith-Petersen incision.

The site of the osteotomy should be about five centimeters distal to the lesser tro-

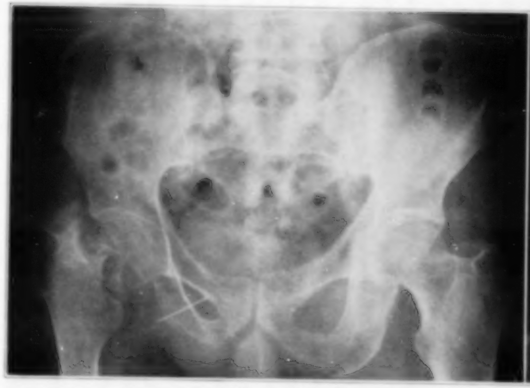


FIG. 9-A

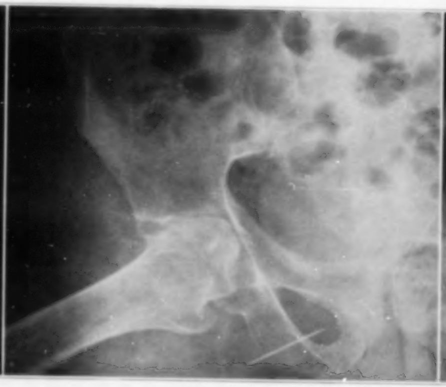


FIG. 9-B

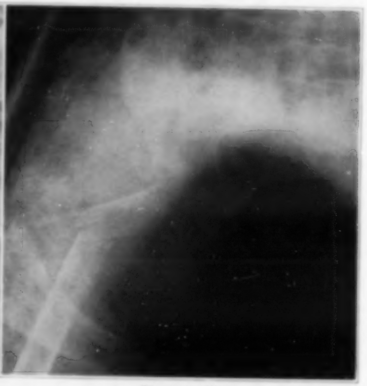


FIG. 9-C

Fig. 9-A: Case 1. The roentgenogram showed non-union and absorption of the femoral neck after injury.
Fig. 9-B: Roentgenogram made three months after arthrodesis of the hip in wide abduction.
Fig. 9-C: Roentgenogram made after osteotomy of the femur.

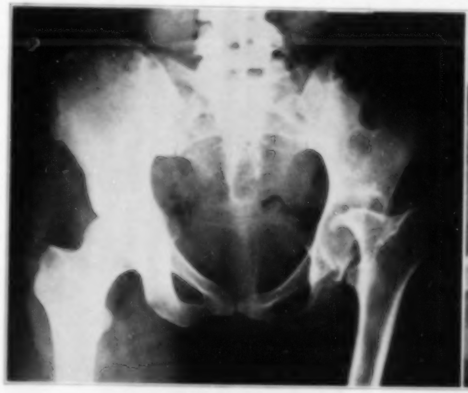


FIG. 10-A

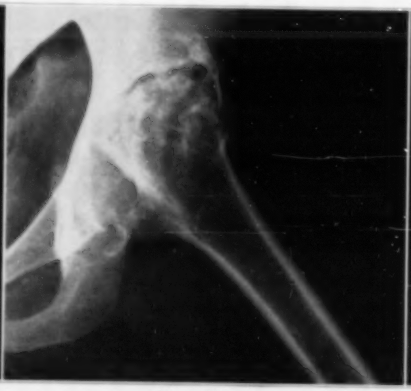


FIG. 10-B

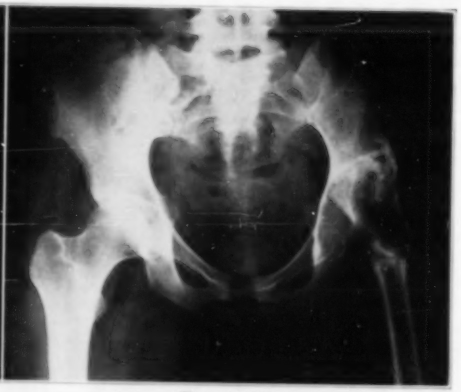


FIG. 10-C

Fig. 10-A: Case 2. Preoperative roentgenogram, showing massive destruction of the hip following tuberculosis.
Fig. 10-B: Roentgenogram made four months after arthrodesis of the hip in wide abduction.
Fig. 10-C: Roentgenogram made after osteotomy of the femur and gradual bending of the callus.

chanter. If it is too high, the blood supply to the trochanter may be impaired. The periosteum is elevated only enough to expose the lateral cortex. Usually the bone is cut about three quarters of the way across and the medial cortex is fractured. The shaft is then adducted and displaced slightly inward, so that the medial cortex of the proximal fragment fits into the medullary cavity of the distal fragment, thereby locking the two and providing good contact (Fig. 9-C). While we prefer a position of abduction of 5 to 10 degrees, flexion of 35 degrees, and lateral rotation of 10 degrees, the final positioning of the extremity depends on the preference of the individual surgeon. A new bilateral hip spica cast is applied and the final position is again checked by roentgenograms. This cast is maintained until the site of the osteotomy has healed. Weight-bearing is resumed gradually, and shortening is compensated with a heel lift.

The average amount of shortening in our cases was 3.1 centimeters and varied according to the amount of bone destruction in both the acetabulum and the greater trochanter. If there has been no destruction, the amount of shortening will be about 2.5 centimeters, as shown in Figure 8. The total functional shortening will depend also upon the degree of fixed flexion and upon the ability of the patient to compensate by movement in the lower back.

CASE REPORTS

The following cases are illustrative of the method of arthrodesis of the hip in wide abduction. Case 1 represents a destruction of the hip due to injury. Case 2 illustrates massive destruction of the joint following tuberculosis.

CASE 1. A male, aged sixty-two, entered the Hospital in December 1953 for severe pain in his right hip, resulting from non-union of an old fracture of the femoral neck. His right lower limb from the hip to the knee was four centimeters shorter than the left as a result of poliomyelitis at the age of nine months. Roentgenograms of the pelvis showed resorption of the right femoral neck and diffuse osteoporosis.

Arthrodesis in wide abduction was performed on February 11, 1954. The femoral head was discarded and the acetabulum was denuded of articular cartilage. The remnant of the neck was excised, and a snug fit of the greater trochanter in the acetabulum was obtained. A bilateral hip spica was applied, with the right lower limb in abduction of 70 degrees, flexion of 35 degrees, and external rotation of 10 degrees.

On May 13 the cast was removed and a subtrochanteric osteotomy was performed. At the time of operation the fusion site was found to be solid. The extremity was adducted, and a new spica cast was applied with a final position of flexion of 35 degrees, abduction of 12 degrees, and external rotation of 10 degrees. At the time of writing the patient was still in immobilization, awaiting union at the site of osteotomy.

CASE 2. A female, aged twenty-four, entered the Hospital in May 1947, complaining of pain and stiffness in the left hip. A diagnosis of tuberculosis of the hip had been made when she was thirteen years of age. After conservative therapy for a period of three years, she had minimal disability until pain and limitation of movement developed when she was twenty-two years old.

Arthrodesis of the hip in wide abduction was performed on May 27, 1947. After excision of the joint, the trochanter was placed in the acetabulum, and bone chips were packed in the vicinity of the fusion site. A bilateral hip spica was applied, with the left extremity in abduction of 40 degrees.

Subtrochanteric osteotomy was performed on October 3, 1947, four months later, through a window in the cast. No attempt was made to place the limb in a functional position at this time. The patient re-entered the Hospital a month later. At that time the cast was removed, and with traction the extremity was brought to a final position of flexion of 30 degrees and abduction of 5 degrees.

When the cast was removed on February 27, three months later, the hip was ankylosed and there was solid fusion at the site of the osteotomy. The left extremity was functionally five centimeters shorter than the right.

SUMMARY

Abduction arthrodesis provides the following conditions favorable to union: a large area of contact between cancellous-bone surfaces with excellent circulation, firm apposition, and good immobilization. Important to the maintenance of contact at the site of fusion is the axial impaction provided by the tightness of the adductor muscles.

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DISCUSSION

Dr. Rudolph S. Reich, Cleveland, Ohio: The method of Dr. Abbott and Dr. Lucas appears to be a radical departure from the many methods of intra-articular and extra-articular arthrodesis and yet it makes use of the prime principles necessary for success in arthrodesis of the hip. The most important principle is tight apposition of living and healthy bone and this is achieved by denuding the trochanteric and acetabular surfaces, which are adjacent. Firm fixation is accomplished by the position of abduction, which makes a compressing force of the adductor tendons acting through the shaft of the femur. The other essential principle for success in arthrodesis is complete immobilization. This is aided by the abducted position which causes the adductor tendons to compress the denuded surface of the trochanter against the acetabulum. Later, immobilization is aided by the osteotomy which effectively destroys the lever arm during the important period of consolidation of the arthrodesis.

The osteotomy is best performed in the middle postoperative period, so that its position may be followed during the time of healing. This has proved useful because, in our experience, it is extremely difficult to maintain an optimum position, particularly with children, and many patients have required an osteotomy to correct a deformity after arthrodesis. The only apparent deterrent to this operation is residual shortening. In the cases which have been presented shortening was already present and would seem to me to be increased by the operation which superimposes a coxa vara on the pre-existing shortening. The authors describe an average shortening of 3.1 centimeters, which suggests that some patients had much more shortening. This is certainly not a serious situation in children, but the correction of limb-length discrepancy in adults requires more consideration.

In studying the illustrations I was struck by the fact that the osteotomy in the sketch is at a higher level than on the roentgenograms of the patients reported. The authors advocate directing the osteotomy at some point below the hip, lest it jeopardize circulation, which in turn would influence the end result of the hip fusion. In view of the fact that the osteotomy is not recommended until there is assurance of arthrodesis of the hip joint, I do not think that the site of the osteotomy would appreciably influence the circulation in the hip. Obviously the higher the osteotomy, the less sacrifice of limb length will result.

The results reported by the authors and those of Kirkaldy-Willis and Mbuthia seem to indicate a higher percentage of successes, with a shorter period of immobilization than has generally been reported.

The authors have recommended their operation for cases in which a prosthesis has failed; this is a new indication for the procedure. While we have had little experience with prostheses, I cannot help but feel that this is a very timely paper, if only for this single reason.

I wish to congratulate the authors for presenting a method of hip fusion which produces a greater percentage of primary hip fusions and does not require bone-grafting or the use of metal for a successful arthrodesis.

Dr. Walter P. Blount, Milwaukee, Wisconsin: Dr. Abbott has outlined the various techniques of arthrodesing hips. His ingenious method is applicable particularly to children who have tuberculosis with marked destruction of the hip joint. I understand that his two failures in tuberculosis were cases in which sinuses and secondary infection were present.

In such advanced cases, arthrodesis by any method is precarious, particularly when there is destruction of the greater trochanter. I should like to suggest instead the use of the bifurcation operation of von Baeyer and Lorenz. It was called the *Gabelung* or "forking" operation when used in this way.

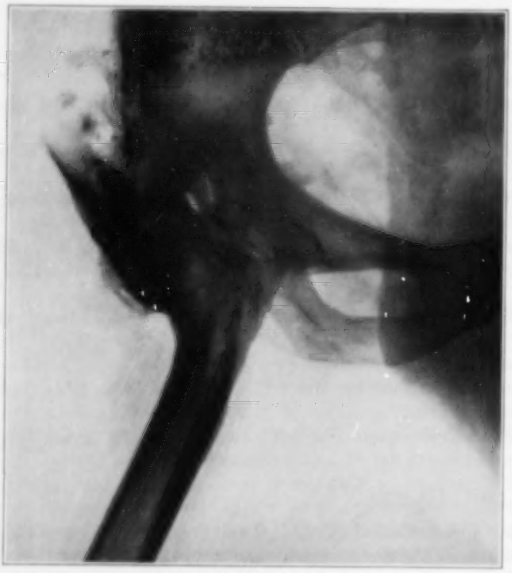

Fig. A

B. W., thirty-two years old. The patient had advanced tuberculous disease of the right hip with multiple draining sinuses and general debility. The anteroposterior roentgenogram of the right hip was made six years after a "forking" osteotomy in which the tip of the proximal fragment was thrust into the acetabulum. The extremity was widely abducted. This compensated for shortening of ten centimeters. The patient walked much better and his general physical condition had improved greatly. The hip had clinically solid union.

An oblique subtrochanteric osteotomy is done and the distal fragment is angulated into abduction. The proximal end of this segment is thrust into or toward the acetabulum. The proximal fragment is adducted (Fig. A). An abduction cast is applied. This is removed as soon as the site of the osteotomy shows solid fusion and the patient begins walking with crutches. In some cases a bony ankylosis develops; in some there is a fibrous union. Either way, the patient's situation is much improved. The diseased material is not excised, but motion is obliterated and healing is permitted.

Dr. Abbott offers his arthrodesis for use also when an endoprosthesis fails. We all agree that in such a case an arthrodesis is a difficult procedure and that, to assure solid bony union, a method such as Dr. Abbott's is justified. I should like to go a step further, however, and say that, if an arthrodesis is indicated, it should be done in the first place instead of inserting an endoprosthesis. An endoprosthesis should be used only when there is a definite contra-indication to arthrodesis, a less mutilating operation which gives a more permanent result. If there was a contra-indication to arthrodesis in the first place, the failure of the first operation certainly does not constitute an indication for stiffening the hip. If motion was urgently necessary before, then motion is still an important desideratum after the failure of the endoprosthesis. Either the patient should walk with crutches and accept the shortening, as they do following Girdlestone's operation, or some operation should be performed which preserves motion but at the same time diminishes shortening and provides stability.

Such an operation was described by me in 1943 [a] and has been used effectively by Milch [d] and Batchelor.[c] It can be employed in this type of case unless there is a pre-existing knock-knee deformity. It consists of a one-stage double osteotomy comprising, first, resection of the head and neck and, second, a subtrochanteric osteotomy with angulation medially and anteriorly and use of internal fixation. In a case reported by me [b], with a ten-year follow up, the end result was good motion in flexion and extension but very little motion otherwise.

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(Continued on page 1189)

HYPEREXTENSIBILITY OF THE PROXIMAL INTERPHALANGEAL JOINT OF THE FINGER FOLLOWING TRAUMA

BY ROBERT B. PORTIS, M.D., LOS ANGELES, CALIFORNIA

From the Veterans Administration Center, Los Angeles

An unhealed avulsion of the palmar portion of the proximal interphalangeal joint capsule leads to a characteristic deformity and disability. The finger cannot be fully extended in the normal manner, because the proximal interphalangeal joint immediately subluxates into hyperextension and the distal joint falls into partial flexion (Figs. 1-A through 1-F). Hyperextension of the proximal interphalangeal joint is accompanied by herniation of the head of the proximal phalanx through an aperture in the palmar aspect of the capsule, which is bounded distally by the base of the middle phalanx and proximally by the edge of the avulsed capsule. The hyperextension of the proximal interphalangeal joint is then maintained by the bow-string action of the extensor tendons and at times by partial incarceration of the head of the proximal phalanx when the capsular aperture fits snugly about it. In some instances, the tense separate bands of the normally divided flexor sublimis tendon, lying laterally upon the palmar portion of the capsule, also grasp the head of the proximal phalanx. In both of the cases presented here, hyperextension, which occurred when active extension of the proximal interphalangeal joint was attempted, could be reduced only by external assistance and the reduction was accompanied by an audible snap. The abnormal hyperextension of the proximal interphalangeal joint relaxes the extensor tendon mechanism for the distal interphalangeal joint. The flexor profundus tendon is no longer normally opposed and the distal joint falls into partial flexion.

The deformity is not present if the finger is relaxed, but it recurs whenever complete active extension is attempted. Flexion in the proximal and distal interphalangeal joints is usually normal, both actively and passively, unless other joint injuries are present. If the proximal interphalangeal joint is passively prevented from hyperextending, the distal interphalangeal joint will actively extend normally and completely.

The abnormality in passive motion which is constantly present in these cases is hyperextensibility of the proximal interphalangeal joint. At times as much as 90 degrees of extension dorsally is possible beyond a straight line. The usual average extent of hyperextension of the proximal interphalangeal joint ranges from 0 to a little over 10 degrees.

Mild increased hyperextension of the proximal interphalangeal joint has been shown in conditions other than avulsion of the palmar portion of the capsule and may be associated with flexion of the distal interphalangeal joint. Bunnell showed photographs of a similar but milder deformity in a "limber or double-jointed" hand. Such hyperextension may also occur gradually in cases in which the normally divided sublimis tendon has been resected too close to its insertion, as in the repair of a laceration of the profundus tendon in a finger. Hyperextension may also occur in the proximal interphalangeal joint following an unrepaired rupture of the extensor apparatus to the distal phalanx in drop-phalangette or mallet finger. A form of the deformity is sometimes found in rheumatoid arthritis involving the hand.

Two cases of avulsion of the palmar portion of the capsule of the proximal interphalangeal joint have been explored surgically. The trauma in Case 1 was produced when a ball struck the tip of the finger and presumably hyperextended it sharply. In Case 2 the finger was injured by the steering wheel in an automobile accident. In both instances the proximal interphalangeal joint was dislocated. After reduction, the fingers were treated by extension in tongue-blade splints for brief periods. This immobilization in extension apparently did not close the defect caused by the avulsion of the palmar aspect of the capsule. The avulsion of this portion of the capsule may at times be associated with a chip fracture at the palmar aspect of the base of the middle phalanx. As might be expected, injuries of the collateral ligaments may be concomitant with the capsular tears and lead to persistent lateral subluxation of the joint.

CASE 1. J.D., twenty-seven years old, was a patient at the Neuropsychiatric Hospital of the Veterans Administration at Los Angeles. On March 6, 1950, the patient caught a baseball directly upon the tip of his right little finger. He stated that the first joint of the finger was dislocated backward, but he reduced it himself. He was treated with a tongue-blade splint for two weeks. He soon noted that the finger snapped into an abnormal position whenever he tried to extend it. The first joint overextended and the end joint flexed at the same time (Figs. 1-A, 1-B, and 1-C). The finger became fixed in this position and he could release it only by manipulating it with the other hand. The reduction was accompanied by a snap and was painful, as was the position of deformity. The discomfort became gradually more severe and moderate swelling persisted.

Upon examination on November 12, 1950, the proximal interphalangeal joint was found to be moderately swollen and tender. There was, however, extension to 45 degrees beyond a straight line passively. When the patient attempted to extend the finger actively, the proximal interphalangeal joint suddenly assumed a position of hyperextension at approximately 35 degrees beyond a straight line and the distal interphalangeal joint could not be actively extended beyond 155 degrees. When the proximal interphalangeal joint was passively prevented from hyperextending, the patient could actively extend his distal interphalangeal joint to 180 degrees.

At surgical intervention on November 28, 1950, a longitudinal mid-lateral incision was made in the little finger (Fig. 1-D). The flexor tendon sheath was incised longitudinally at the level of the proximal interphalangeal joint. The flexor digitorum profundus tendon was retracted, so that the pathological condition was revealed. The palmar capsule of the proximal interphalangeal joint of the right ring finger was found to be completely avulsed from the base of the middle phalanx and was retracted proximally; through the aperture which remained most of the head of the proximal phalanx could be seen when the joint was subluxated. Over the medial and lateral edges of the aperture lay the halves of the normally divided sublimis tendon. When the joint was hyperextended, the head of the proximal phalanx herniated through the aperture and was grasped by the edges of the avulsed capsule and by the slips of the taut sublimis tendons. The extensor tendon apparatus dorsal to the joint spanned away from the bone and the distal joint assumed a position of slight flexion. As the proximal interphalangeal joint was reduced from its hyperextended position, the head of the

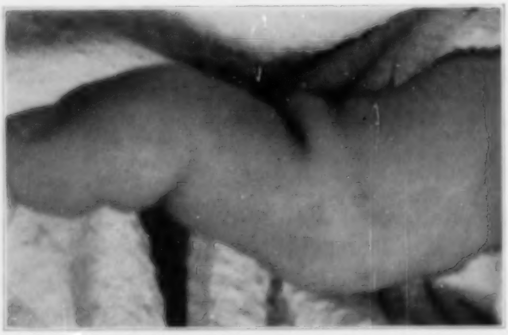

FIG. 1-A

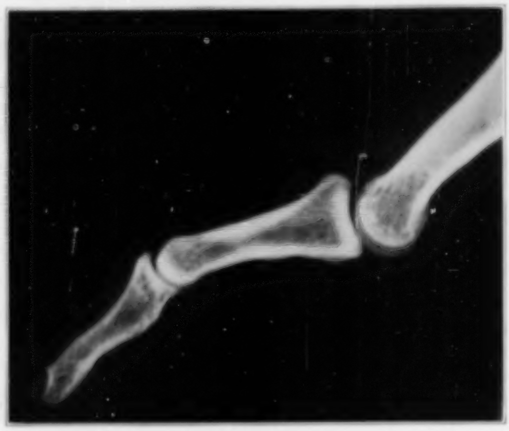

FIG. 1-B

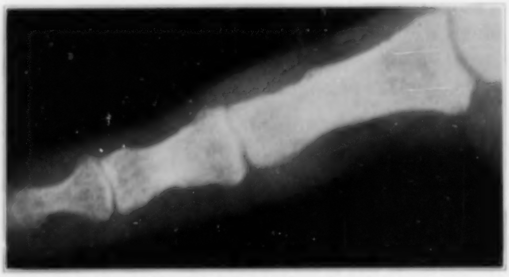

FIG. 1-C

Fig. 1-A: Case 1. Showing the little finger in the position of deformity.

Fig. 1-B: Lateral roentgenogram of the little finger in the position of deformity.

Fig. 1-C: Anteroposterior roentgenogram of the little finger in the position of deformity.

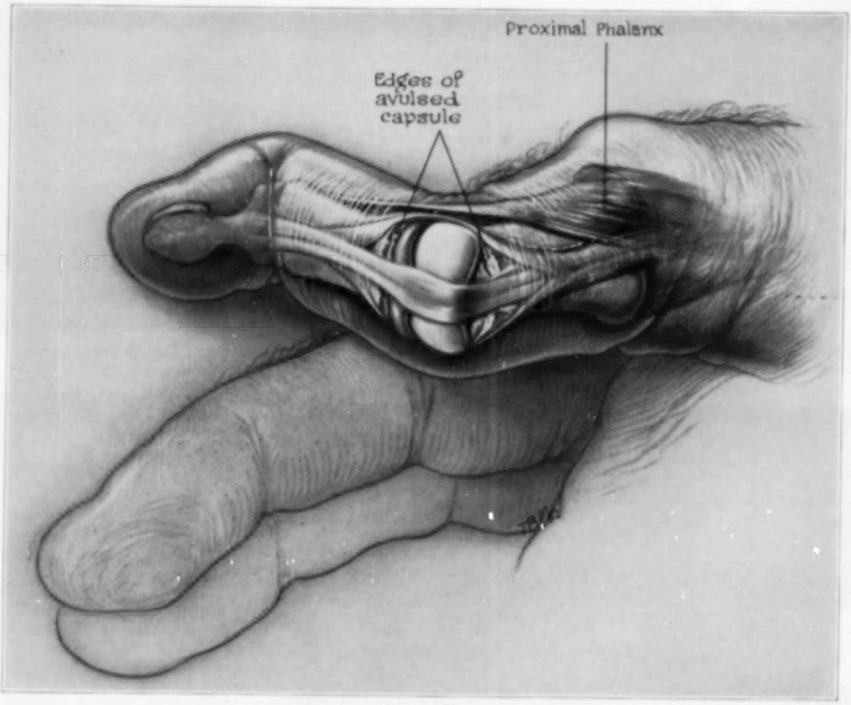

Fig. 1-D

Drawing illustrating the pathological condition in Case 1, with the finger in the position of deformity. Note the edges of the avulsed capsule, enclosing a portion of the head of the proximal phalanx.

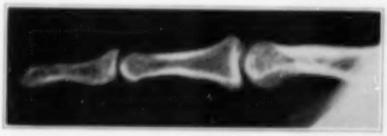

Fig. 1-E

Lateral and anteroposterior roentgenograms of the finger in strong active extension after the period of rehabilitation.

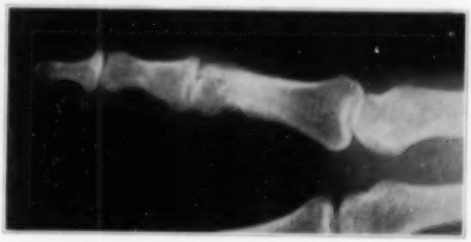

Fig. 1-F

proximal phalanx snapped back through the aperture and returned to its normal position in the joint. In the repair, the avulsed capsule was sutured with interrupted silk sutures to its normal insertion in the base of the middle phalanx after the edges had been freshened. This satisfactorily prevented hyperextension of the joint.

The finger was maintained in moderate flexion by means of plaster-of-Paris immobilization until January 4, 1951. At that time the proximal interphalangeal joint extended to about 165 degrees and flexed to 140 degrees. Physical therapy consisting of heat and active and passive exercises was instituted. By July 15, 1951, seven months after operation, the range of motion included active flexion beyond 90 degrees and complete extension to 180 degrees (Figs. 1-E and 1-F). The distal interphalangeal joint extended actively to 180 degrees. The patient reported only occasional mild discomfort and slight swelling. There was no tendency for the deformity to recur. Passive hyperextension of the proximal interphalangeal joint was now impossible. The patient could not be followed after his release from the Neuropsychiatric Hospital.

Case 2. K. J. J., forty-three years old. The patient's left ring finger was examined on January 13, 1953, while he was convalescing from an emergency appendectomy at the General Medical and Surgical Hospital of the Veterans Administration at Los Angeles, California. He stated that, twenty years before, a car which he was driving had struck another car. The impact had apparently forced his hand against the steering wheel and had dislocated the left ring finger at the proximal interphalangeal joint. The dislocation was

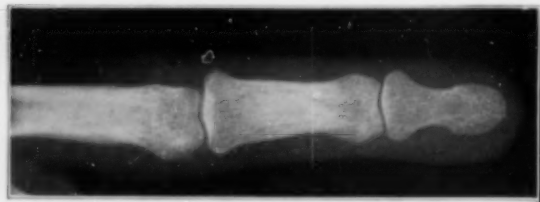

FIG. 2-A

Figs. 2-A through 2-D: Roentgenograms of the left ring finger made just before surgery.

Fig. 2-A: Anteroposterior roentgenogram made with the finger in extension.

Fig. 2-B: Lateral roentgenogram, made with the finger in slight flexion, showing two small avulsed fragments of bone adjacent to the proximal interphalangeal joint.

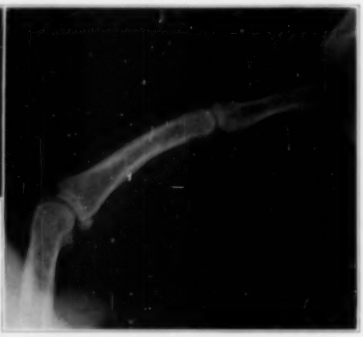

FIG. 2-B

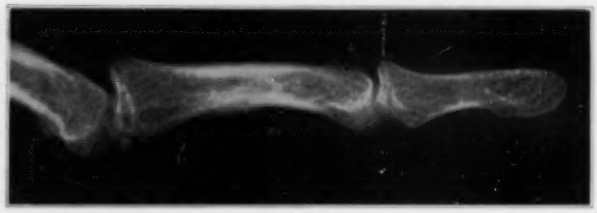

FIG. 2-C

Lateral roentgenogram of the finger in spontaneous subluxation.

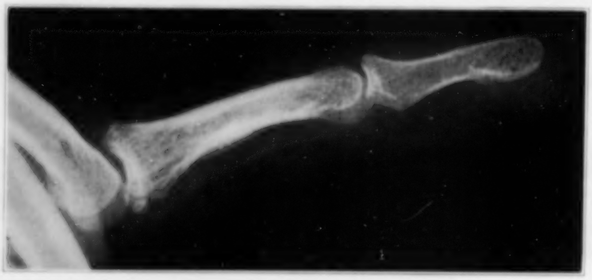

FIG. 2-D

Fig. 2-D: Lateral roentgenogram showing extent of maximum passive hyperextension of the proximal interphalangeal joint.

reduced and the finger was splinted in extension for a few days.

In 1941, in the Army, the patient dislocated the same finger during physical training. Soon afterward he again dislocated it while catching a heavy box.

Shortly before being examined the patient had been having a great deal of difficulty with the left ring finger. When he attempted to extend it completely, or if he knocked the tip of the finger lightly against anything, as in reaching into his pocket, the finger suddenly went into a dislocated position with the proximal interphalangeal joint fixed in hyperextension and the distal interphalangeal joint somewhat flexed. These episodes were associated with pain. Reduction was effected only by manipulation with his other hand.

Anteroposterior and lateral roentgenograms of the left ring finger on January 18, 1953 (Figs. 2-A through 2-D), revealed two small areas of increased density lying near the volar aspect of the base of the middle phalanx; these represented bits of avulsed bone. Roentgenograms made with the finger in subluxation revealed the marked hyperextension of the proximal interphalangeal joint. The region of the proximal interphalangeal joint was moderately swollen symmetrically and diffusely tender.

Surgical intervention on January 20, 1953, was conducted under brachial plexus block anaesthesia. A longitudinal incision centering upon the proximal interphalangeal joint was made along the ulnar aspect of the ring finger in the mid-plane to avoid the nerves. Bleeding was controlled by a pneumatic tourniquet. The flexor tendon sheath was identified and incised, the flexor sublimis and profundus tendons being exposed at the proximal interphalangeal joint. The flexor profundus was retracted laterally to expose the palmar surface of the proximal interphalangeal joint. A substantial defect was noted in the palmar aspect of the joint capsule. The capsule was avulsed from the base of the middle phalanx. A small fragment of bone was attached to the free edge of the capsule, and another small fragment was embedded within the site of avulsion at the base of the middle phalanx. The capsule itself was found to be detached from the middle phalanx. It was displaced proximally and folded under the head of the proximal phalanx. It was noted that with very little pressure the proximal interphalangeal joint suddenly fell into hyperextension and the head of the proximal phalanx herniated through the rent in the capsule and became fixed in this position. The two slips of the flexor sublimis tendon were tight about the neck of the proximal phalanx and the flexor profundus

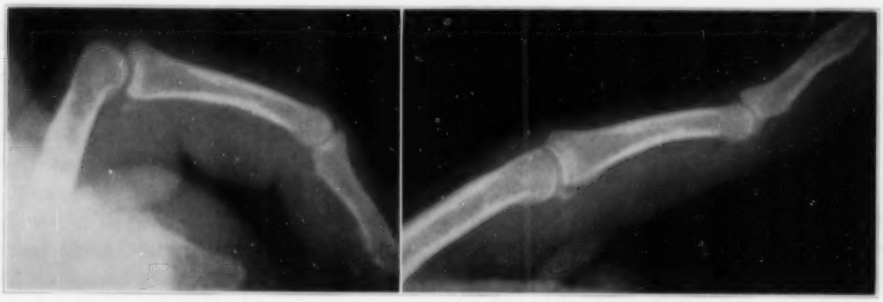

FIG. 2-E

FIG. 2-F

Lateral roentgenograms, made on August 24, 1953, showing forced passive flexion and forced passive extension of the proximal interphalangeal joint.

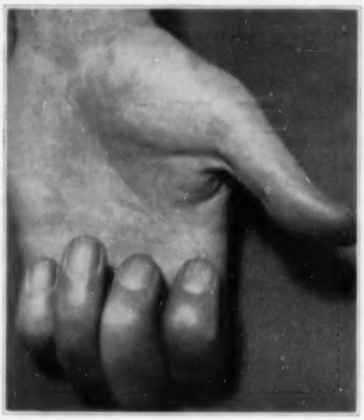

FIG. 2-G

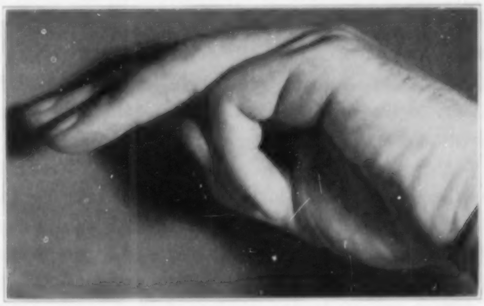

FIG. 2-H

Photographs of the left ring finger, taken July 31, 1953, showing the range of active motion, with no tendency toward subluxation.

coursed between the condyles of the palmar aspect of the head of the proximal phalanx. The tension on the flexor profundus caused some flexion of the distal interphalangeal joint in this position.

In repairing the defect the small fragment of bone was excised from the free edge of the avulsed capsule and, with moderate flexion of the proximal interphalangeal joint, it was possible to bring this edge to the base of the middle phalanx. Two small drill holes were placed through the medial and lateral thirds of the base of the middle phalanx in an anteroposterior direction. A wire suture was run through the free edge of the palmar capsule and was inserted through the drill holes, a pull-out wire being left for later removal of the suture. The ends of the wire suture were brought out dorsally and tied over a button. At this time it was seen that it was impossible to extend the proximal interphalangeal joint beyond 135 degrees. The proximal insertion of the palmar portion of the capsule upon the proximal phalanx was then stripped from the bone by sharp dissection and the capsule was allowed to shift distally until the joint extended to approximately 170 degrees. The tourniquet was removed and hemostasis was obtained. The pull-out wire was brought through a needle hole in the palmar aspect of the finger. The wound was then closed in layers and a dry dressing with plaster-of-Paris immobilization was applied, the finger being maintained at approximately 155 degrees of extension at the proximal interphalangeal joint. The pull-out wires were removed on February 10, 1953, but the finger was maintained in the same position of splinting for a period of six weeks from the time of surgery. Mobilization of the finger was assisted by physical therapy. The patient has gradually improved.

On August 20, 1953, extension of the proximal interphalangeal joint was approximately 175 degrees actively, flexion was possible to 85 degrees, and the patient could bring the tip of his finger to within one centimeter of the middle palmar flexion crease. He had no feeling of instability in the finger and no pain. It was impossible to force the finger into the position of deformity. The patient was able to use the finger normally (Figs. 2-G and 2-H). The swelling and tenderness which had been originally present about the proximal interphalangeal joint had almost completely disappeared. By December 4, 1953, the finger could be extended actively to 175 degrees and flexed to 70 degrees at the proximal interphalangeal joint. There was no tendency for the deformity to recur.

Four reports concerning avulsion of the palmar portion of the proximal interphalangeal joint capsule have been discovered in the literature. Bunnell showed a drawing of the typical deformity and described a case in which the proximal interphalangeal joint of a little finger was bent backward and dislocated while the patient was pushing a log. The reduction had been incomplete and a posterior subluxation of the middle phalanx remained, with the finger fixed in extension. The case differed from the two here presented in that the patient did not flex the joint in making a fist. The injury proved to be a complete avulsion of the palmar aspect of the proximal interphalangeal joint capsule. Repair was accomplished surgically and two months later the finger joints could be flexed almost normally. No mention was made of hyperextensibility. Roemer mentioned injury to the proximal interphalangeal joint with a resultant deformity similar to that in the cases described in this report. He showed photographs of a case and an anatomical dissection to demonstrate the probable mechanism of injury. Bate in 1945 described a similar condition in the little finger of an aviator. In exposing the joint he used a longitudinal incision through the collateral ligament of the proximal interphalangeal joint. The rent in the capsule was sutured and the collateral ligament was repaired in such a way as to tighten the palmar portion. The instability and subluxation did not recur, and the patient was relieved of his disability. A flexion contracture at 160 degrees persisted in the proximal interphalangeal joint. Two apparently similar cases were described by Kaplan in 1936. He performed dissections on two cadavera and concluded that rupture of the anterior capsule and of the collateral ligaments of the proximal interphalangeal joint of a finger was necessary to produce the characteristic deformity. In the cases reported in this series, the collateral ligaments appeared to be functionally intact and only the palmar aspect of the capsule was repaired.

The type of deformity found in the cases described appears superficially to be due to a mechanism similar but opposite to the often reported buttonhole injury of the proximal interphalangeal joint, which occurs after avulsion of the middle slip of the long extensor tendon. Actually, however, the two conditions are not related at all. The defect in our cases was not in a tendon insertion but in the palmar aspect of the joint capsule.

Injuries in the region of the insertion of the palmar portion of the proximal interphalangeal joint capsule into the base of the middle phalanx are not rare. According to Roemer, in a series of 800 lateral roentgenograms taken at random from the files of the shipyard First Aid Station at the Northern Permanente Hospital, there were nine definite and eight probable fractures of the palmar lip of the base of the middle phalanx, the site of attachment of the palmar portion of the capsule.

The best treatment would seem to consist in immediate adequate reduction of the dislocation, if present, followed by sufficiently prolonged immobilization of the joint in moderate flexion. Late treatment, if necessary, consists in surgical suture of the avulsed capsule to the base of the middle phalanx and subsequent adequate immobilization and rehabilitation. This operation should usually not be undertaken for cosmetic reasons. The indications for surgery are persistent pain and swelling and sufficiently disabling instability in selected cases.

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TISSUE-CULTURE STUDIES OF BONE *

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The purpose of this paper is to describe several tissue-culture methods for studying bone-cell growth and differentiation and to present an application of these techniques in determining the viability of cells after storage by freezing. While this is not intended as a complete evaluation of the possible techniques for tissue culture of bone or for storage of bone as a viable tissue, cellular survival has been demonstrated by the methods described, following dehydration and slow freezing.

METHOD

Tissue-culture techniques for the study of bone growth and differentiation have been reported by Strangeways and Fell [17,19,20,58], among others. The techniques used in the present experiment were based fundamentally on Fell's method. However, several modifications were introduced. Two culture methods have been employed, the roller-tube technique [12,23,46] and the Maximow slide-culture technique [39,40].

In the tube-tissue-culture technique, an ordinary test tube is used. The lower half of the tube is coated inside with a thin layer of chicken plasma, and the bone is anchored in place on the wall of the tube with a small drop of dilute chick-embryo juice. One to two milliliters of medium is added. The test tube, corked with a rubber stopper, is incubated horizontally at 37 degrees centigrade. The roller-tube apparatus [16,22], although not essential, is a desirable instrument for incubating tube cultures, since with it continual washing of the tissue with nutrient fluid is possible. When the medium becomes acid †, the fluid is removed and replaced with fresh medium. Fairly rapid digestion of the clot occurs with young, vigorously growing tissue. However, the tissue can be transplanted into fresh tubes, or the plasma can be patched to re-anchor the tissue.

The tube technique has several advantages: (1) Tissue viability can be determined quickly, since the fluid medium contains an indicator which facilitates the recording of pH changes; (2) chemical determinations (for instance, alkaline phosphatase) can readily be carried out on the fluid medium; and (3) daily observations of the cellular outgrowth from the bone can be made under low-power microscopy. On the other hand, there are several inherent disadvantages in this technique: (1) The method apparently supports the growth of fibroblasts at the expense of bone development; (2) when rapid fibroblastic proliferation occurs, it is necessary to transplant the tissue to fresh tubes frequently (a procedure not without technical difficulties); and (3) it is difficult to obtain satisfactory photographs or *camera lucida* drawings of the growing tissue.

The use of "flying-cover-slip" cultures [51] in large part eliminates the problems inherent in the simple tube-culture method (Fig. 1, *A*). The tissue, instead of being anchored on the wall of the test tube, is anchored by means of a plasma clot to the surface of a cover slip. The tissue fragments are spaced in a linear arrangement and the slip is inserted in the test tube. The tube is corked, and, approximately one hour later, two milliliters of nutrient fluid is added and the tube is incubated horizontally at 37 degrees centigrade. While microscopic observation is possible with a 3.2-millimeter objective, the chief ad-

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† The term "acid", as used in the text, refers to a change in the color of the indicator, phenol red, added to the culture medium. The change from red ("alkaline") to yellow ("acid") occurred at pH 7.4 when checked with the Beckman pH meter. When specific hydrogen-ion concentrations are mentioned in the text, they were determined with the latter instrument.

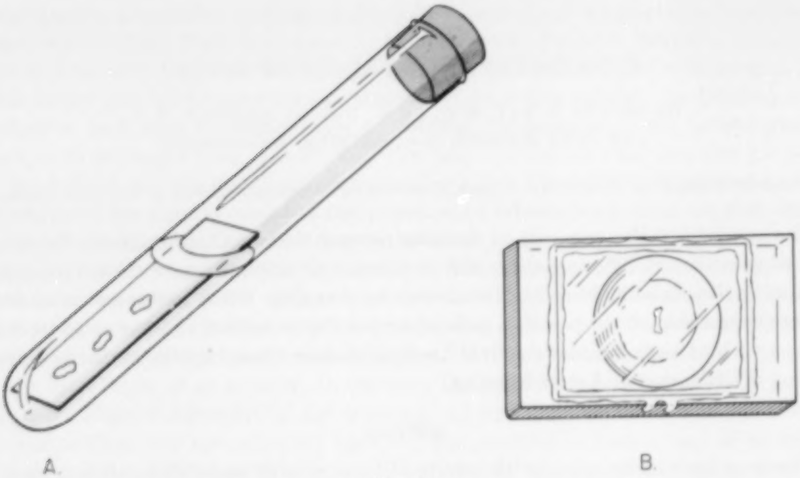

Fig. 1

A: Drawing to illustrate the "flying-cover-slip" technique (actual size, 150 by 16 millimeters).
B: Drawing to illustrate the Maximow deep-well culture method (actual size, 45 by 75 millimeters).

vantage of this method is that the slip can be removed for photomicrographs and *camera lucida* drawings and for staining the tissue *in situ*.

In the second method, the Maximow double-cover-slip technique, the tissue is planted in a plasma clot on the surface of a small cover slip, which is then fixed to the center of a larger cover slip by means of a drop of fluid. The latter is inverted over the well of a Maximow slide and sealed into place with paraffin. The small cover slip can be removed at intervals and bathed in fluid medium without disturbing the tissue. For small pieces of tissue and for high-power microscopic study, this method is excellent. However, it is impractical for large pieces of tissue in which one wishes to observe both growth and differentiation.

This method has been modified for large bone chips by planting the fragment on the surface of a large plasma clot established in the center well of a Maximow slide (Fig. 1, *B*). A cover slip is superimposed over the depression and sealed with paraffin, and the slide is incubated upside down to avoid excessive condensation of water on the inner surface of the cover slip. This type of slide culture, similar to Fell's watch-glass technique, provides an adequate surface area for growth and differentiation and at the same time avoids excessive proliferation of fibroblasts and rapid liquefaction of the plasma clot. Low-power microscopic observation of the explant is possible when the slide is viewed from the bottom, and serial *camera lucida* drawings or serial macrophotographs can be made.

MEDIA

Two types of media are used for tissue cultures: chemically undefined natural fluids and extracts, and chemically defined solutions. In the present study, only the first type of medium, with the exception of a defined salt solution, was used. The main ingredients included chick-embryo extract, horse or human serum, chicken plasma, and Hanks' balanced salt solution[27].

The chick-embryo extract was prepared from eleven-day embryos. These were removed aseptically from the eggs and homogenized in a sterile electric homogenizer. The homogenate was diluted with an equal volume of Hanks' balanced salt solution. One hundred units of penicillin and 100 micrograms of streptomycin per milliliter of the mixture were added. The homogenate was centrifuged and the supernate was removed, dispensed in thirty-milliliter quantities, and stored at −18 degrees centigrade until needed.

The chicken plasma was collected by drawing thirty milliliters of blood from the wing vein or from the heart of a young rooster and mixing it with 0.15 milligram of heparin contained in a three-milliliter solution of heparin sodium. The blood was centrifuged, and the plasma was drawn off and stored in the refrigerator.

Horse serum (Difco) was used for culturing embryonic rat femora; human serum was used for the culture of human bone. The human serum was obtained by centrifuging clotted human blood. The serum was stored in the refrigerator until needed.

The addition of antibiotics to the final medium — in addition to those added to the embryo extract — was optional. When they were added, the concentration was 100 units of penicillin and 100 milligrams of streptomycin per milliliter of final medium. Media were adjusted to pH 8.3 to pH 8.4 with 1.4 per cent. sodium bicarbonate.

Concentrations of the nutrients were varied according to the method of culture employed, as follows:

	Per cent.
1. *Tube Medium*	
Chick-embryo extract	10
Hanks' balanced salt solution	40
Horse serum or human serum	50
2. *Double-Cover-Slip-Slide Medium*	
Horse serum or human serum	50
Chick-embryo extract	50
Clot: two drops of the above mixed with two drops of chicken plasma.	
3. *Deep-Well-Slide Medium*	
Horse serum or human serum	50
Chick-embryo extract	50
Clot: three drops of the above mixed with nine drops of plasma.	

PROCEDURE

Embryonic Rat Femora

Embryonic rat femora, seventeen to eighteen days old, were used in the initial experiments. At this age, the femur, composed primarily of cartilage, can be dissected free from the surrounding tissues with a minimum of difficulty, and yet it is young enough to exhibit, in tissue culture, subsequent growth and differentiation. With aseptic technique and use of fine forceps and iridectomy scissors, the hind limbs of the embryos were dissected in a Petri dish containing about twenty milliliters of Hanks' balanced salt solution, transferred to another Petri dish containing five milliliters of Hanks' solution, and the muscle and connective tissue were cleaned off under a binocular dissecting microscope. The femur was then ready for planting. The stripped bone was transferred with a wide-mouthed, bent-tipped pipette and deposited on the surface of the clot. Excess fluid was removed with a micropipette. When the deep-well-slide-culture method was used, the fibroblastic outgrowth from the explant was trimmed every third to fifth day and the bone was transferred to fresh medium. This was accomplished with the aid of microforceps and specially sharpened cataract knives. As noted by Fell and others [14,18], the fibroblastic outgrowth must be kept at a minimum, since it not only depletes the nutrients of the medium, but also causes distortion of the bone.

Human Cancellous Bone

Fresh chips of human bone obtained at operation were placed immediately in Hanks' solution, and, after the excess blood had been washed away in fresh Hanks' solution, the chips were cut into pieces about 2.5 to 3.0 millimeters in diameter with Littauer suture scissors. Bone fragments less than 2.0 millimeters in diameter did not grow so well or so quickly on culture as pieces which were slightly larger. The most successful method of initiating growth in the human bone fragments was found to be in tubes; little or no proliferation occurred when the fresh tissue was implanted in slide cultures. However, once growth had been established in tube cultures, it was possible to transfer the tissues to slide cultures; subsequent cellular outgrowth on slide cultures was comparable to that in the tubes. To transfer the tissue, the old plasma clot and the cellular outgrowth surrounding the explant were first cut away, since retention of the old clot in making the transfer apparently inhibited the proliferation of new cells from the explant.

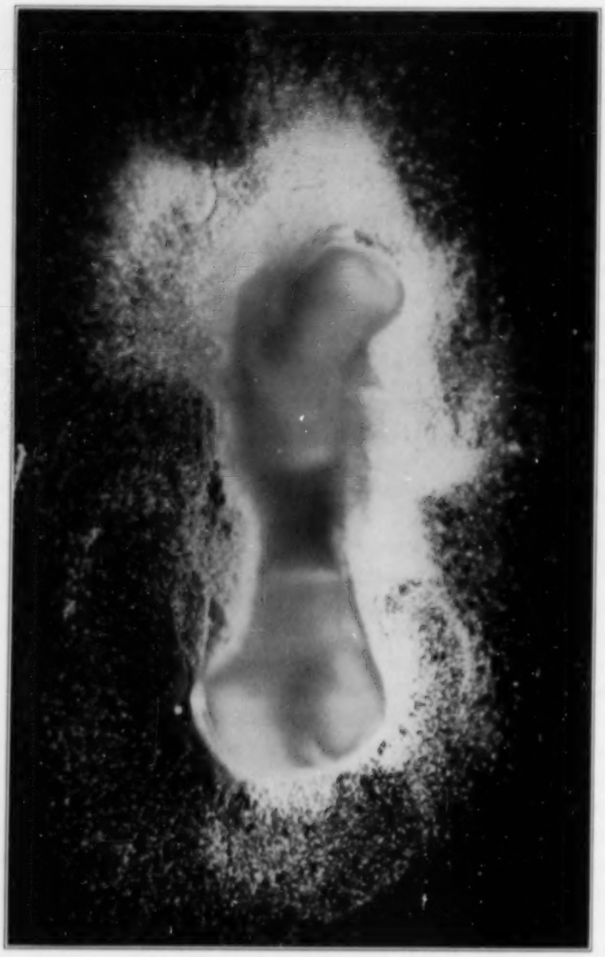

Fig. 2

Macrophotograph (× 11) of eighteen-day embryonic rat femur maintained for six days in a flying-cover-slip culture. Note the "halo" of fibroblastic outgrowth, used as one index of survival of the implant.

APPLICATION OF PROCEDURE

The foregoing methods have been applied to test survival of bone after preservation by the slow-freeze method [8,9,47,50,55,56]. Bone chips were bathed for two to three hours in 15 per cent. glycerol in serum at room temperature. They were then placed in vials containing 15 per cent. glycerol in serum and these were hermetically sealed. In accordance with Smith's technique [55], the vials were suspended in a Dewar flask containing 95 per cent. ethyl alcohol. To this was added powdered carbon dioxide, so that the temperature was lowered at a slow, fairly constant rate — approximately one degree centigrade every minute, from room temperature to 0 degrees centigrade and from 0 degrees centigrade to −78 degrees centigrade in successive stages, with three to four minutes at each stage. The bone was stored at −78 degrees centigrade and later rapidly thawed at 40 degrees centigrade in a water bath, bathed in Hanks' salt solution, and immediately planted in tissue cultures, the tube or the flying-cover-slip type of culture being used. Control cultures of unfrozen femora, bathed for two to three hours in a glycerol-serum bath or in Hanks' solution before being cultured, were carried out simultaneously.

Viability was determined by gross changes in size of the explants, lowering of the pH of the culture media, the production of fibroblasts or other cellular outgrowth, and the appearance of the tissues on histological section.

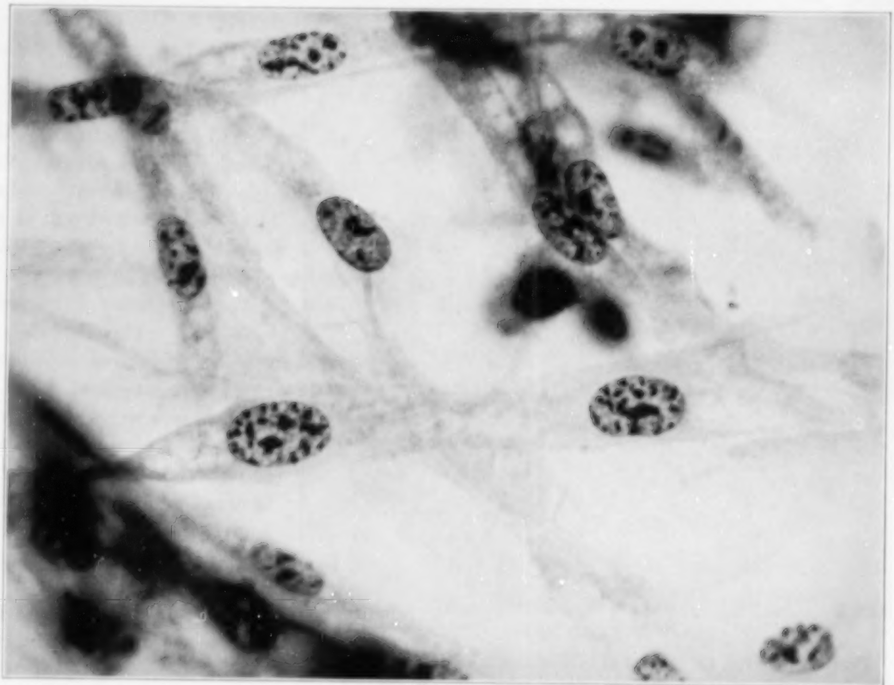

FIG. 3

Photomicrograph (× 1100) of typical "healthy" fibroblasts occurring in the outgrowth from an eighteen-day embryonic rat femur, maintained for eleven days in a flying-cover-slip culture. (May-Grünwald-Giemsa stain.)

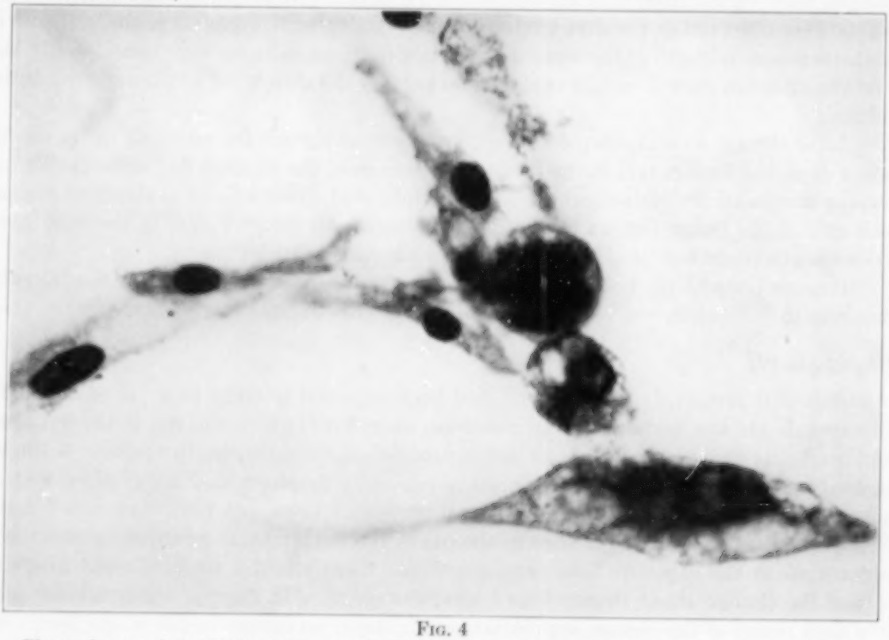

FIG. 4

Photomicrograph (× 1100) of degenerating fibroblasts in the outgrowth from an eighteen-day embryonic rat femur, maintained for ten days without fluid change in a flying-cover-slip culture. The figure illustrates the rounding of the cytoplasm ("balling"), appearance of vacuoles and granules in the cytoplasm, and loss of nuclear detail. (May-Grünwald-Giemsa stain.)

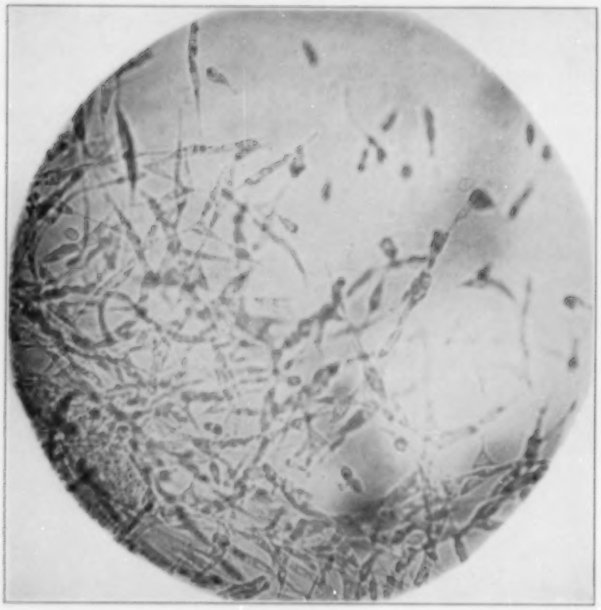

FIG. 5

Photomicrograph (× 500) of fibroblastic outgrowth from eighteen-day embryonic rat femur after storage for ninety-seven days at −78 degrees centigrade and subsequent culture for three days on a flying cover slip.

RESULTS

Gross Changes in Size

Measurements of the length of normal eighteen-day embryonic rat femora have been carried out at intervals on twenty-six cultures (Table I). The majority of the cultures were of the deep-well-slide type, although a few double-cover-slip cultures were also used. Most of the cultures were terminated between the ninth and the fourteenth day, since the femora reached a maximum length during this interval. With further incubation, they increased only in width.

At onset, the eighteen-day embryonic femora varied from 3.35 millimeters to 4.25 millimeters in length; at the end of two weeks of tissue culture, they varied from 4.35 millimeters to 5.6 millimeters in length. The greatest increments were observed in the first twelve cultures (Cultures No. 22a through 7e, Table I), while increases in length of the femora on the last fourteen cultures were considerably less. The variations in growth can be explained in part by the distortion which occurred during culture.

After storage at temperatures of −78 degrees centigrade for intervals up to ninety-seven days, the femora lacked the tissue translucence of the controls and were chalky and opaque in appearance. Subsequent growth was inhibited; there was no evidence of increase in length of the frozen femora in any of the cultures. All cultures were of the tube type, since growth could not be obtained with the slide-culture technique.

Human bone chips, both untreated and frozen, showed no changes in size following tissue culture. Growth was confined to cellular outgrowth from the explant.

Changes in pH

As noted previously, the medium had been adjusted initially to a pH of 8.3 to 8.4. Incorporated in the medium was an indicator, phenol red, which was red at the initial pH and gradually changed to yellow during incubation of the cultures. In the case of the untreated rat femora, the indicator changed to yellow by the third to fifth day of incubation, at which time the pH of the cultures ranged between 7.1 and 7.6. Following slow freezing of the femora, however, the change in the pH of the medium was retarded, apparently in proportion to the exposure time: exposure from three minutes to forty-eight hours retarded the change about twenty-four hours; storage at −78 degrees centigrade for fifty-five days retarded the change approximately six days; no change in pH of the media was observed in the cultures of the femora stored for eighty-four and ninety-seven days at −78 degrees centigrade (Table II).

The medium for culturing human bone was adjusted to the same initial pH, and, by

TABLE I

GROWTH MEASUREMENTS (IN MILLIMETERS) OF EIGHTEEN-DAY EMBRYONIC RAT FEMORA

Culture No.	Days of Tissue Culture 0	1	2	3	4	5	6	7	8	9	10	11	12	14
22a		3.80			4.30		4.90		5.25			5.50		5.60
10a		3.95			5.00		5.15				5.50			5.60
10b		3.58			4.45		4.80				5.05			5.30
* 4f				2.80								4.00		
* 4d				2.75								3.80		
11f	3.80	4.20		4.30				4.85				5.25		
11e		3.85		4.10				4.80		5.00				
11h		4.00		4.30				4.95						
11g		4.10		4.40				5.10						
11c		4.25		4.60	4.80									
11d		4.20		4.50										
7e	3.35							4.15						
5a			4.40							4.80		4.85		
5b			4.40							4.70		4.70		
4a				2.85						3.25		3.255		
4b				2.85						3.25		3.25		
22c		3.85			4.15		4.40		4.65			4.95		4.85
22d		3.90			4.35		4.60		4.70			5.05		4.95
22b		3.95			4.35		4.60		4.75			4.95		4.80
22f		4.00			4.10		4.40		4.50			4.85		4.70
22g		3.90			4.05		4.20		4.60			4.70		4.70
22h		4.05			4.35		4.50		4.65			4.90		4.90
22i		4.00			4.10		4.25		4.55			4.60		4.65
22e		4.10			4.35		4.50		4.60			4.85		4.80
22l		3.70			3.80		3.95		4.45			4.50		4.45
22j		3.65			3.80		4.05		4.45			4.30		4.35

* Seventeen-day embryonic femora.

TABLE II

DAY OF CULTURE ON WHICH CHANGE IN pH OF MEDIUM WAS OBSERVED

Treatment of Bone before Culture	Embryonic Rat Femora		Human Bone	
	No. of Cultures	Day of pH Change	No. of Cultures	Day of pH Change
None.	17	Third to fifth	11	Third to seventh
In Hanks' balanced salt solution 1 to 3 hours.	3	Third	13	Third to fifth
In glycerol-serum 1 to 3 hours.	2	Third	25	Tenth
Stored at −78° C. for 3 minutes.	4	Sixth		
Stored at −78° C. for 1 hour.			2	Eleventh
Stored at −78° C. for 48 hours.	2	Fourth	2	Seventeenth
Stored at −78° C. for 7 days.			1	Twenty-first
Stored at −78° C. for 11 days.			2	Seventeenth
Stored at −78° C. for 55 days.	1	Tenth		
Stored at −78° C. for 77 days.			3	None at thirty-fifth
Stored at −78° C. for 84 days.	1	None at fourteenth		
Stored at −78° C. for 97 days.	1	None at third *		

* Culture harvested for photomicrographs.

the third to seventh day of incubation, the pH changed to 7.2 to 7.6. The change in pH lagged behind cellular outgrowth, and in several cultures did not occur until the seventh day. Treatment of the bone for one to three hours in Hanks' salt solution had no apparent lag effect on the change in the pH of the medium; treatment with glycerol-serum caused a lag of five to six days in the change, but this was not as great as the lag which occurred following storage at −78 degrees centigrade (Table II).

Fibroblastic Proliferation

A "halo" of cellular outgrowth from the periphery of the embryonic rat femur occurred as early as twenty-four to forty-eight hours after culture (Fig. 2). The predominant cell in this halo was a typical fibroblast, with an elongated nucleus and stellate cytoplasmic processes (Fig. 3). In cultures in which the medium had not been changed at regular intervals these cells developed granular cytoplasm and became rounded, or the cytoplasm became vacuolated — changes which were interpreted as evidence of cellular degeneration (Fig. 4). There was no evidence of osteoid matrix or of collagenous fibrils in the outgrowth (in contrast to the outgrowth from adult human bone).

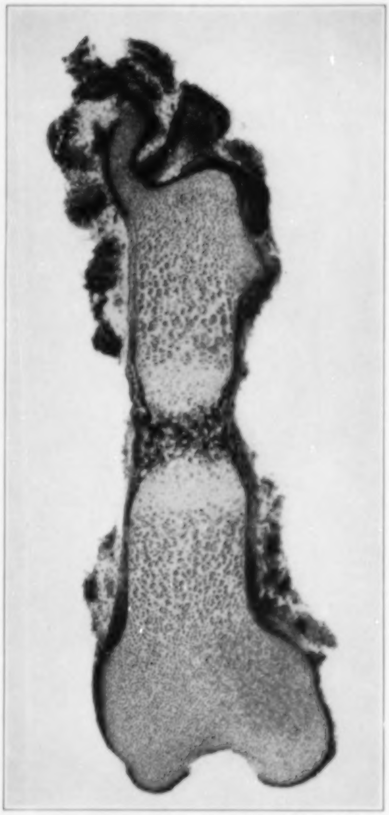

FIG. 6

Macrophotograph (× 38) of normal eighteen-day embryonic rat femur used as control. (Mallory azan stain.)

After being frozen and stored at −78 degrees centigrade for periods up to three months, the embryonic rat femora were still viable, as evidenced by the cellular outgrowth (Fig. 5). However, deleterious effects were observed following this treatment. Exposure for three minutes at −78 degrees centigrade caused a lag in the appearance of the fibroblasts of approximately six hours. After storage at −78 degrees centigrade for twenty-four hours or longer, attempts to cultivate the femora on slide cultures were no longer successful. In tube cultures, in addition to the delay in the outgrowth of fibroblasts, subsequent cellular proliferation, although successful, was slow; the outgrowth occurred in a haphazard fashion from isolated loci (rather than radiating from all points as in the control femora), and many of the cells had granular cytoplasm. A single exception occurred in the femur preserved for ninety-seven days and cultured with use of the flying-cover-slip method. In this instance, the fibroblastic outgrowth approximated that of the controls, and the cytoplasm of the cells did not appear granular.

Fibroblastic proliferation did not occur in less than seventy-two hours of incubation in the cultures of untreated adult human cancellous bone. The use of heterologous serum in the medium apparently was an impediment to growth. Not only was there a delay in fibroblastic proliferation, but varying degrees of fibroblastic degeneration were observed. It was difficult to obtain growth of fresh bone chips with the slide-culture method, and the few fibroblasts produced were granular and degenerated in appearance. Once growth had been established in a tube culture, however, the explants could be transferred to a slide culture successfully.

With tube cultures of fresh human cancellous-bone chips, outward migration of blood

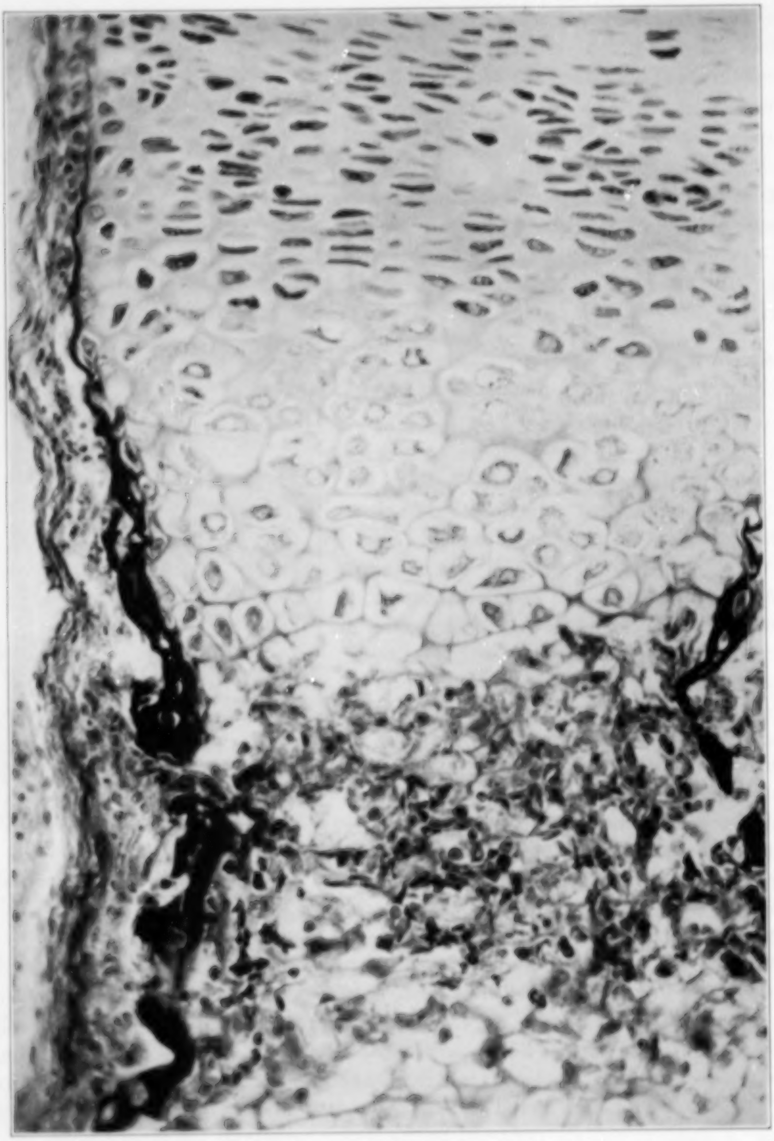

FIG. 7

Photomicrograph (× 230) of the perichondral-periosteal junction of a normal eighteen-day embryonic rat femur illustrating the histological appearance of the zone of endochondral ossification. (Mallory azan stain.)

cells (leukocytes) occurred. When the tissue had been bathed initially in glycerol-serum before being cultured, many of the leukocytes were destroyed. A typical fibroblastic halo was laid down around each explant by the fourth or fifth day of incubation.

Tube cultures of human adult cancellous bone stored at −78 degrees centigrade for periods up to seventy-seven days revealed that the bone remained viable, but the tissue had apparently been damaged by low-temperature preservation. As in the case of embryonic rat bone, the rate of cellular outgrowth was definitely diminished. Tissue cultures of bone stored at −78 degrees centigrade up to eleven days showed only a few fibroblasts between the fourth and sixth day of incubation, the number of fibroblasts increasing slightly by the eleventh day of culture. The initial fibroblasts were granular and degenerative in appearance. However, with continued culture, some explants recovered from the damage inflicted by low-temperature preservation, and subsequent growth of the fibroblasts assumed a normal pattern: a typical fibroblastic halo formed around each explant; the cells proliferated rapidly and appeared agranular.

Two of three tissue cultures of human bone stored at −78 degrees centigrade for seventy-seven days showed only a few fibroblasts after twenty-two days of incubation, and no further outgrowth was observed.

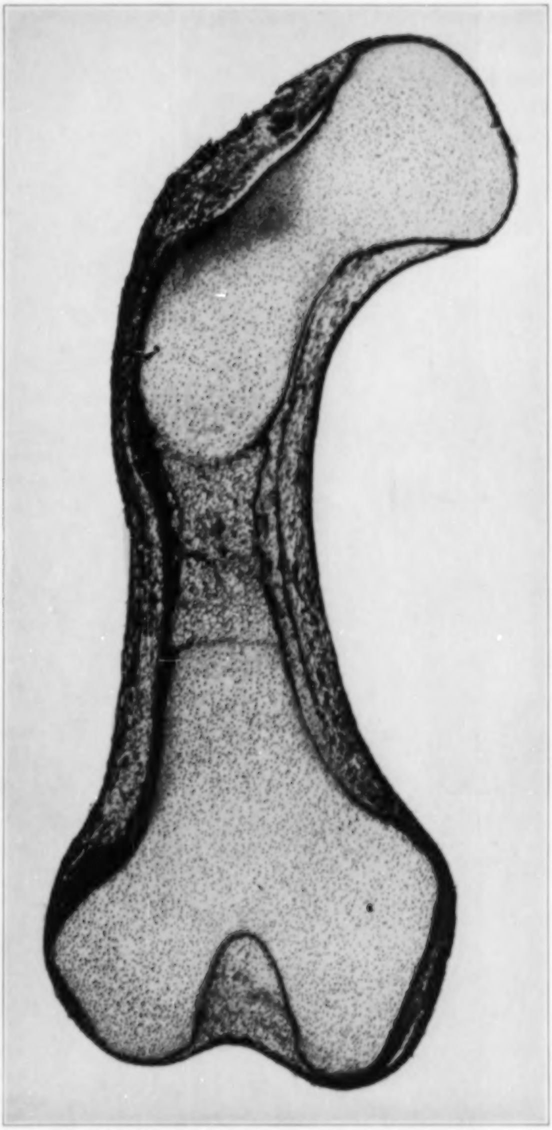

FIG. 8

Macrophotograph (× 38) of an eighteen-day embryonic rat femur after fourteen days in deep-well-slide culture. The figure illustrates the increase in size of the bone (compared with Fig. 6), the increase in width of the zone of ossification, and the subperiosteal-subchondral proliferation. (Mallory azan stain.)

Histological Studies

At eighteen days, the general contour of the embryonic rat femur is established — femoral condyles, greater trochanter, and head (Fig. 6). A single center of ossification is present in the middle of the diaphysis, with a zone of vascularization extending across the shaft. Beneath the periosteum in this region, there is a thin ring of osteoid matrix and a few cells are incorporated within the matrix. Within the zone of ossification, the vesicular cartilage cells and the intercellular matrix are replaced by vascular elements. The entire zone is approximately 0.225 millimeter in length. On either side of it there is a zone of vesicular cartilage cells in which the lacunae of the cells are large, the cytoplasm of the cells is vesicular in character, the nucleus is large with a prominent nucleolus, and the intervening intercellular matrix is present only as a network of fine trabeculae. This zone is approximately 0.168 millimeter wide. Distal to it, the cartilage cells are arranged in columnar fashion; the nuclei of the cells are small, ovoid, and basophilic; and there is abundant matrix between the lacunae (zone of proliferation or basophilic cells). This zone extends toward either epiphysis. At this stage of development, no centers of ossification have been established within the epiphyses; the

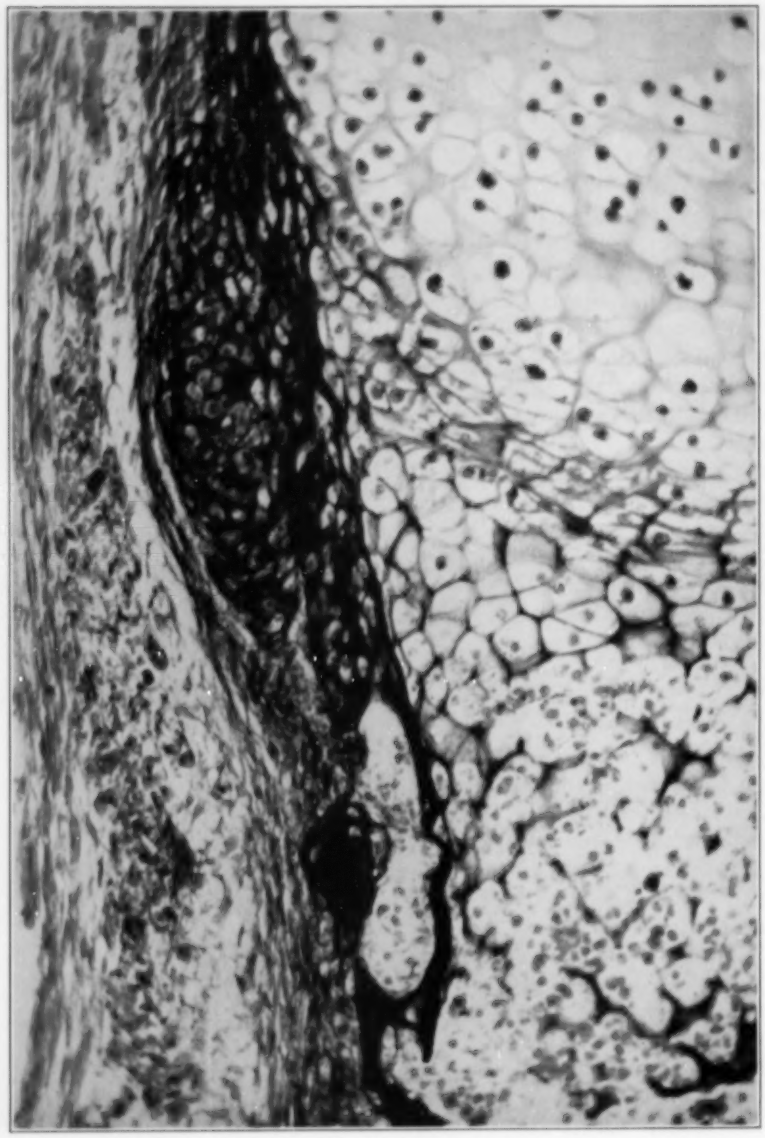

FIG. 9

Photomicrograph (× 230) of the zone of endochondral ossification of the eighteen-day embryonic rat femur illustrated in Fig. 8. The figure shows the production of osteoid matrix at the periosteal-perichondral junction. (Mallory azan stain.)

cells are arranged in the haphazard fashion characteristic of embryonic hyaline cartilage. The two layers of the perichondrium and periosteum are well defined (Fig. 7).

After culture for fourteen days, the embryonic femur retained its general configuration (Fig. 8). The zone of ossification was approximately 0.498 millimeter in length. In addition to the peripheral subperiosteal osteoid ring, there were areas of osteoid matrix within the diaphysis. The myeloid elements, however, were not as distinct as in the uncultured femur. The zone of vesicular cells was narrowed and the nuclei of the cells were pyknotic in character. The zone of proliferation (basophilic zone) was less clearly demarked than in the control; the lacunae of the cells in this area were larger and the nuclei of the cells were pyknotic. The cells peripherally arranged in the epiphyses at either end of the diaphysis appeared normal and nuclear detail could be seen. There was evidence of proliferation of the cambium layer of the perichondrium and periosteum, and, within this layer, abundant collagenous fibers could be distinguished. The outer layer of the periosteum persisted as a dense, longitudinally arranged, fibroblastic membrane (Fig. 9).

As noted previously, the frozen embryonic rat femora did not increase in length on culture, but fibroblastic proliferation was observed. Histological sections revealed a slight increase in the width of the zone of ossification, 0.305 millimeters, compared with 0.225 for the controls (Fig. 10). In the zone of ossification, there were a few areas of eosinophilic-staining matrix where nuclear detail of the cells could be made out (Fig. 11). However, the cartilage cells in the zones of proliferation and vesiculation showed evidence of degeneration, with deeply staining, pyknotic nuclei and little or no cytoplasm (Fig. 12). Within the layers of the periosteum and perichondrium, there were occasional fibroblasts, but evidence of proliferation was not so marked as in the preceding group.

In cultures of fresh human cancellous bone, the lacunae of the bone fragments appeared empty, cellular growth apparently originating from the superficial cells. The predominant cell type was the fibroblast. Collagenous fibers were present. In some areas, there was apparent coalescence of the fibrils and the appearance of an eosinophilic matrix resembling the "osteoid" seen in "primary"[38,57] bone formation. In some of these areas, the cells appeared epithelioid in character (Fig. 13). In addition to the foregoing cell types, occasional plasma cells, tissue eosinophils, macrophages, and lymphocytes were observed.

In the cultures of human bone, frozen and preserved at −78 degrees centigrade prior to culture, similar cell types, as well as osteoid matrix, may be found on examination of the histological sections (Fig. 14).

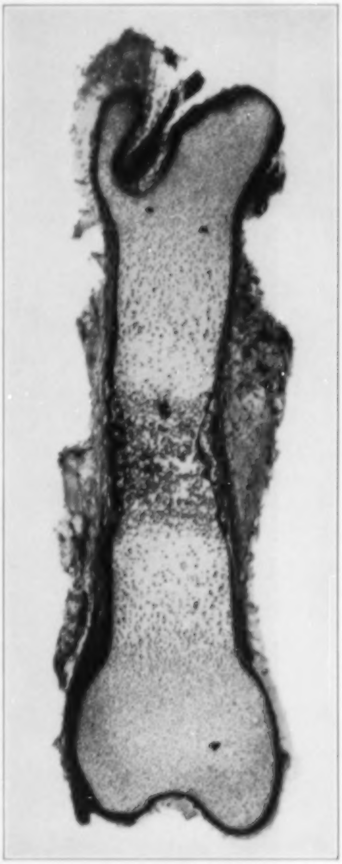

FIG. 10

Macrophotograph (× 38) of an eighteen-day embryonic rat femur following storage for ninety-seven days at −78 degrees centigrade and subsequent culture for three days on a flying cover slip. The figure illustrates the increase in width of the zone of ossification. (Mallory azan stain.)

DISCUSSION

Behind this quest for a method of investigation lie many unanswered questions concerning the problem of bone transplantation. Past attempts to answer these basic questions have resulted in several hypotheses which, in one form or another, have governed the surgeon's attitude toward bone-grafting since the turn of the century. One hypothesis holds that fresh autogenous bone grafts can serve as a source of transplanted cells and that these cells may be of major importance in bridging bone defects, — that is, that the graft plays an active role in the process of repair. The second hypothesis holds that bone grafts become acellular in the first postoperative weeks and undergo creeping substitution, being replaced by new bone derived from the surrounding bed. According to this theory, the graft plays a passive role in the process of replacement. A third theory

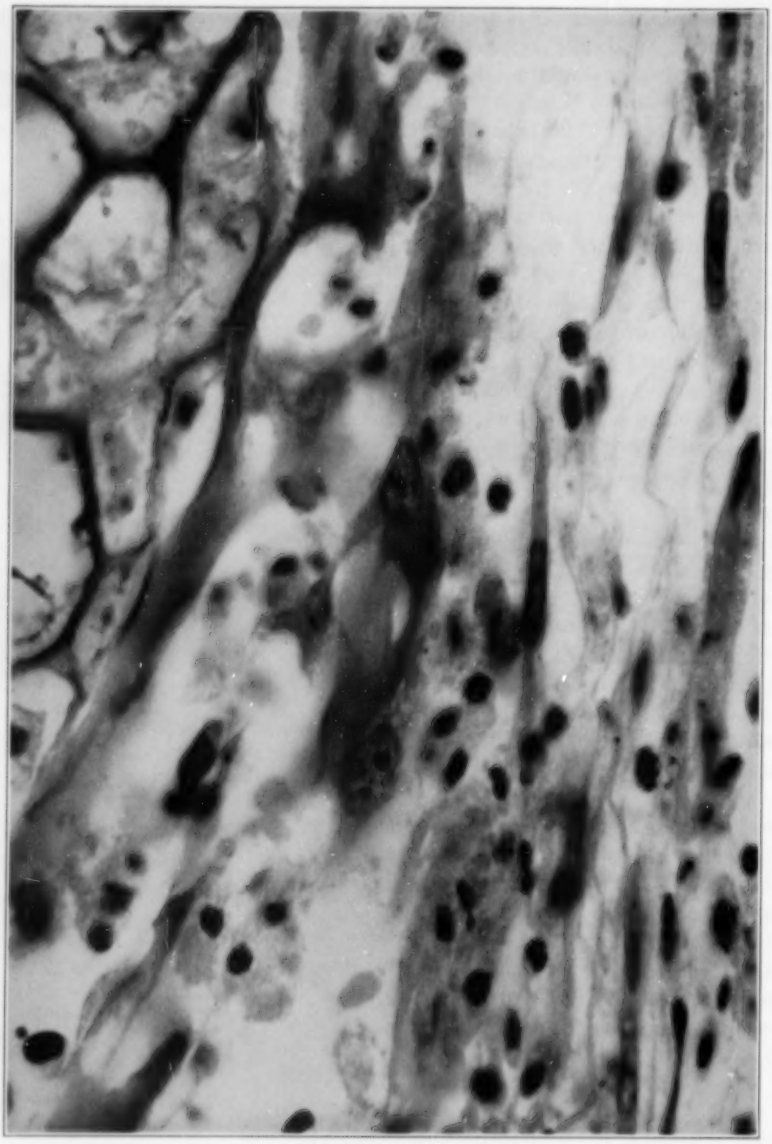

FIG. 11

Photomicrograph (× 1280) of the perichondral-periosteal junction of an eighteen-day embryonic rat femur, following storage for ninety-seven days at −78 degrees centigrade and subsequent culture for three days on a flying cover slip. The figure shows the appearance of the new "osteoid" matrix. (Hematoxylin-eosin stain.)

suggests that the graft, although dead, may in some way stimulate the host cells to form new bone, — that is, that the graft plays an active role in bone replacement independent of its cellular survival.

A vast amount of experimental evidence has been accumulated over the years to prove that autogenous bone cells will survive and proliferate when transplanted to ectopic sites in the body [11, 15, 25, 26, 31, 43, 52, 61]. The tissue-culture experiments of Fell and coworkers, as well as the present experiments, further verify the fact that cells of transplanted bone can survive and proliferate *in vitro*. It is apparent that *in vivo* survival of the cells is dependent

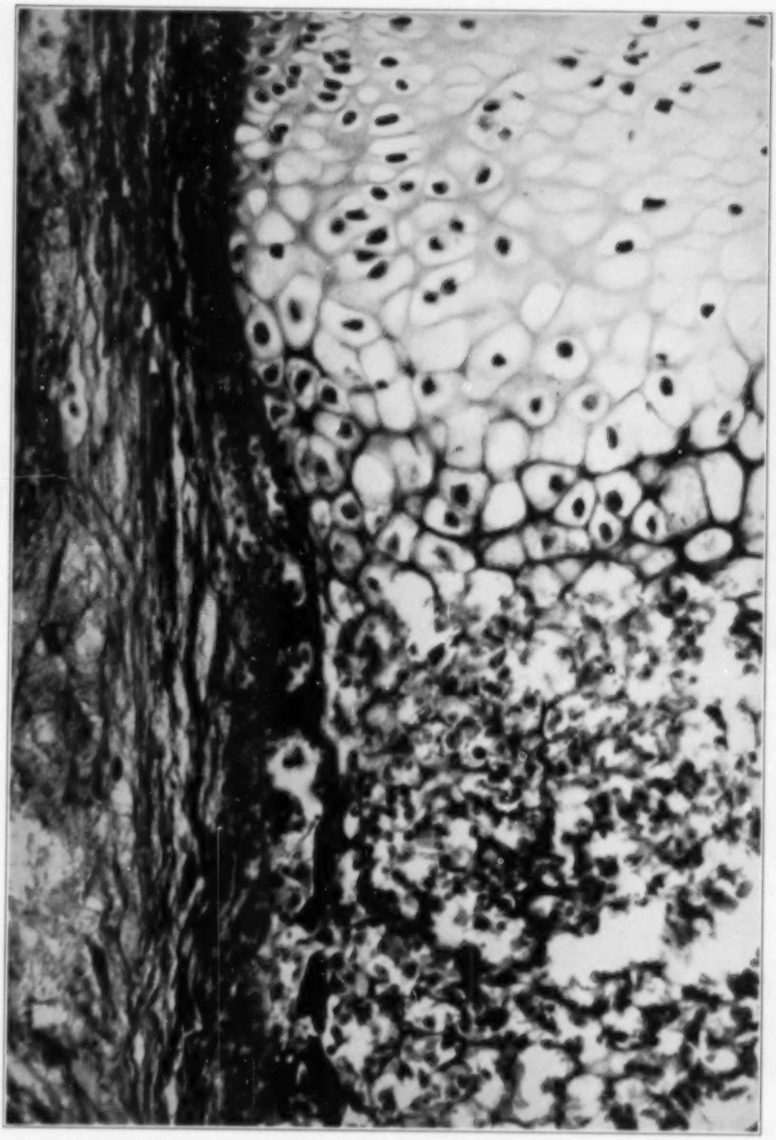

FIG. 12

Photomicrograph (× 230) of the perichondral-periosteal junction of an eighteen-day embryonic rat femur, following storage for ninety-seven days at −78 degrees centigrade, cultured for three days on a flying cover slip. Cellular degeneration, pyknotic nuclei, and disappearance of cytoplasm are evident, but there is some fibroblastic proliferation. (Mallory azan stain.)

upon the diffusion of tissue fluids through the graft and early establishment of circulation to the graft [25, 26]. It is because of these considerations that cancellous bone has been advocated in preference to cortical bone whenever survival of the cells is deemed more important than internal fixation [1].

Although the question of survival of the cells of autogenous grafts has been answered, the question of cellular survival in the case of homogenous bone grafts is still far from settled. Experiments now in progress in this laboratory indicate that fresh homologous

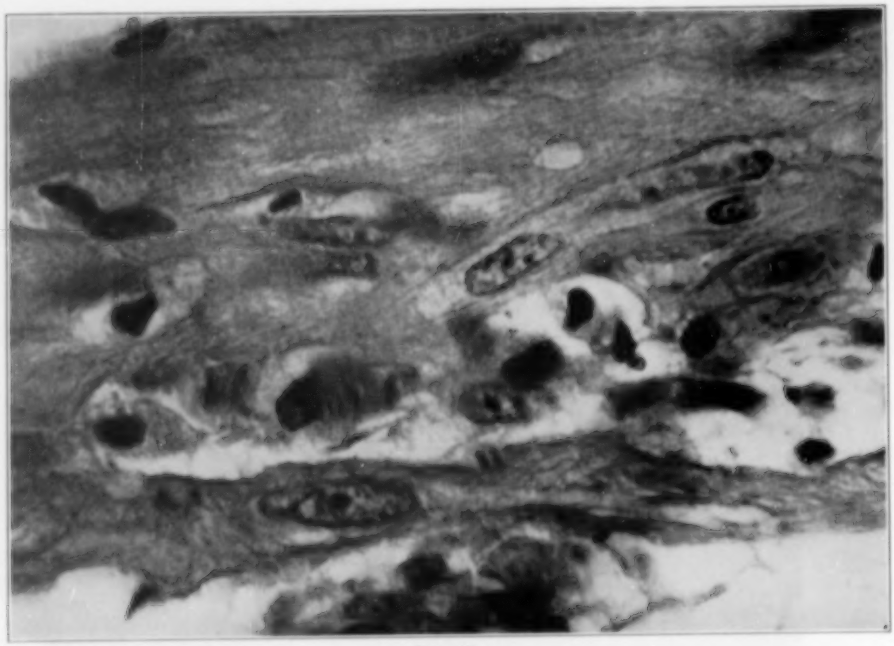

Fig. 13

Photomicrograph of untreated human cancellous bone (× 1040), grown in a regular tube culture for seventeen days, shows the appearance of the new osteoid matrix and the "epithelioid" cells. (Hematoxylin and eosin stain.)

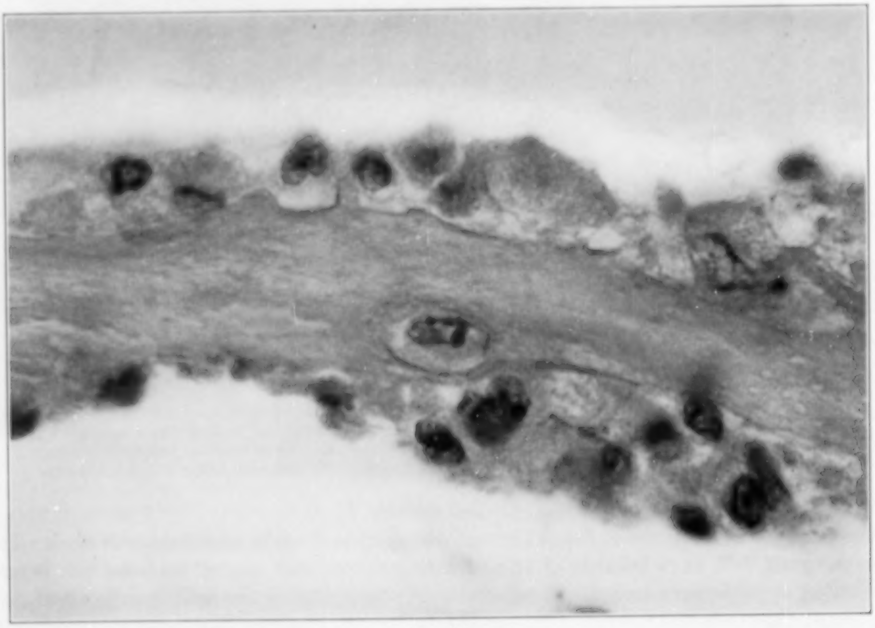

Fig. 14

Photomicrograph of human cancellous bone (× 1040) frozen for forty-eight hours at −78 degrees centigrade and then maintained for seventeen days in a regular tube culture. Note the production of osteoid matrix. (Hematoxylin and eosin stain.)

bone participates in a homologous tissue reaction similar to the reaction described for skin [7, 41]. This may explain the clinical observation that fresh autogenous bone grafts are usually more successful than fresh homogenous grafts.

With regard to the second theory, it has been established beyond reasonable doubt, both clinically and experimentally, that dead bone, whether autogenous, homogenous, or heterogenous [3, 4, 5, 13, 21, 24, 30, 36, 37, 42, 44, 45, 48, 49], as well as synthetic hydroxyapatite crystals [53] will, when placed in skeletal defects, be replaced by new bone. Obviously, from dead bone no cellular outgrowth can occur, and it was concluded that the graft under such circumstances did not "induce" osteogenesis. In recent years, however, this conclusion has been questioned. It has been suggested that such grafts can induce bone formation or metaplasia of the local connective-tissue cells [6]. In support of this theory, Urist and McLean have reported that autogenous grafts, after being frozen for three minutes in carbon dioxide, or boiled for three minutes in normal saline solution will induce bone growth when transplanted to the anterior chamber of the eye [60]. However, the origin of the bone in these and similar experiments is open to question. It must be established that trauma or infection incident to the operation is not the factor responsible for initiating bone formation and also that the cells of the implant are dead. Tissue culture — although its artificiality throws cellular mechanisms under considerable stress — allows a method of observation of cellular growth and differentiation in which the origin of the cells and their viability cannot be questioned.

Another series of experiments to support the "induction" theory of bone formation has been based on injection of extracts of bone into soft tissues, with ensuing ectopic bone formation [2, 33, 35]. That bone formation occurs after such injections, following necrosis induced by trauma or injection of alcohol [27], or in ectopic sites under a variety of clinical conditions (surgical scars, atheromatous plaques, caseous tubercles, and others) still fails to explain the various factors controlling metaplasia of the primitive connective-tissue cells into cells with osteogenetic potentialities. Tissue cultures offer an excellent method of studying the possible extrinsic factors involved in cellular metaplasia.

The advent, in recent years, of bone banks [10, 32, 54, 62] has stimulated interest in the use of homogenous bone in the surgical repair of skeletal defects. Bone preserved by the usual methods is probably not viable *. However, in the preceding experiment it has been demonstrated that, when bone is frozen under the conditions described and then thawed and cultured, cellular outgrowth occurs and an extracellular matrix is formed, with staining characteristics similar to osteoid. It should be emphasized, however, that, while the findings are of interest in the general field of tissue preservation, it is not likely that the method will be of clinical value (except possibly in the rare case requiring a delayed autogenous transplant) until a means can be found to control the tissue reaction which probably occurs in response to homologous grafts of viable bone.

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* Recent reports suggest that frozen cartilage [34] and bone preserved in plasma [59] may remain viable.

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HISTOCHEMICAL STUDIES OF CARTILAGE IMPLANTS *

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INTRODUCTION

In some procedures in orthopaedic and plastic surgery implanted cartilage is used. The fate of these implants has been traced principally by histological studies which have emphasized morphological changes in the cartilage cells, the matrix, and the contiguous tissues of the host. Recently metabolic studies and the subject of cartilage and cartilage implants have been reported [8] and reviewed [11].

From clinical experience it has been determined that cartilage autografts persist for longer periods than preserved homocartilage or preserved heterocartilage. While the presence of viable chondrocytes may be important for the survival of the implant, it appears that other factors are also implicated. Notable among these are the initial physicochemical state of the cartilage ground substance and the interaction between the host tissues and the cartilage matrix.

The ground substance of cartilage contains a carbohydrate-protein complex which is believed to be highly aggregated [1,5,6]. Under certain physiological and pathological conditions the solution of cartilage is accompanied by a disaggregation of this material [1,2,6]. These results suggested that similar processes might occur in the ground substance of implanted cartilage.

To study this problem some histochemical techniques were applied in the investigation of costal cartilage and cartilage implants in the rabbit.

MATERIAL AND METHODS

Sixteen female albino rabbits, approximately two and one-half kilograms in weight and sixty-three days of age**, were used in this study. Eleven experimental animals were grouped according to the duration of cartilage implantation—fourteen, thirty, sixty, 120, 180, and 270 days. Generally, there were two animals for each age group. Each animal received one fresh and one boiled costal autocartilage implant. These henceforth will be referred to as "autografts" and "boiled autocartilage" respectively. Control material consisted of the opposite sixth costal cartilage in animals with implants, the sixth costal cartilage from each of five animals sixty-three days of age and from two animals forty-two days of age without implants. Thus a total of forty-seven specimens were studied: eighteen non-boiled costal cartilages, seven boiled costal cartilages, eleven autografts, and eleven boiled autocartilage implants.

Surgical Procedures

The animals were anaesthetized with an intravenous injection of two to three cubic centimeters of a 3 per cent. solution of pentobarbital sodium. Under aseptic conditions, approximately two centimeters of the sixth costal cartilage without perichondrium was

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** Ages of animals are correctly stated within seven days.

removed and cut into two equal pieces. One piece was implanted immediately into an abdominal subcutaneous pocket on the right side. The other piece was implanted into a similar pocket on the left side after having been placed in boiling distilled water (approximately pH 6) for not less than fifteen minutes.

After the desired period of implantation, the animals were sacrificed by the injection of air into the marginal vein of the ear and the implants were immediately removed with their surrounding connective tissue. The opposite sixth costal cartilage was removed and used as a control.

Preparation of Tissues

Fixation of all cartilage was by freezing-drying. Tissues were immersed in isopentane chilled in liquid nitrogen at −140 to −155 degrees centigrade. They were then dehydrated *in vacuo* at a temperature maintained at −30 degrees centigrade for a minimum period of five days.

After the removal of tissues from the freezing and dehydrating apparatus, they were infiltrated *in vacuo* with paraffin (melting point 55 to 56 degrees centigrade) and cut in cross sections at four to sixteen micra. They were then placed on albuminized slides, except in special procedures, and carefully flattened with finger pressure after being gently heated over a hot plate. Sections were deparaffinized in petroleum ether for ten minutes. The tissues were then denatured in absolute ethyl alcohol for at least twelve hours before being stained.

Histochemical Methods

The method of Hotchkiss and McManus was used to localize carbohydrate-protein complexes and glycogen in the cartilage sections. Polysaccharides, glycoproteins, glycolipids, some uronic acids, simple sugars, and free aldehydes all react positively with the periodic-acid-Schiff reagents. Preliminary treatment of tissue sections with certain reagents and enzymes enhanced the specificity of the method[5]. The distribution of glycogen was determined by noting the location of red-staining granules which could be removed by incubation with β-amylase at 37 degrees centigrade.

Some tissues were stained for metachromatic substances with toluidine blue (1:80,000 and 1:17,500). Tissues were immersed in the dye for periods up to twenty-four hours and the wet preparations were examined.

Identification of other tissue components was also attempted by use of other enzymes prior to staining. Some preparations were treated with hyaluronidase or collagenase * before staining. This was done by placing the tissues in well slides containing the enzyme solutions. The hyaluronidase solution contained 150 turbidity-reducing units per cubic centimeter in 0.15 molar sodium chloride solution at pH 6. Collagenase was made to a concentration of one milligram per cubic centimeter in Palitsch borate buffer, pH 7. The buffer solutions alone were used on neighboring sections which served as controls. The slides were incubated at 37 degrees centigrade for one hour with the hyaluronidase and for one to twenty-four hours with collagenase. Toluidine blue was used to stain tissues treated with hyaluronidase; preparations treated with collagenase were stained with the periodic-acid-Schiff reagents.

The method of Gersh, with minor modifications, was used to localize phosphate or carbonate, or both. Briefly this involved the use of a 60 per cent. silver-nitrate solution saturated with phosphate and chloride ions. The precipitated silver salts were visualized by reduction with ultra-violet light. Morphological details were also studied in sections stained with hematoxylin and eosin.

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* Collagenase supplied through the courtesy of Dr. R. O. Thomson, The Wellcome Research Laboratories, Bechenham, Kent, England. This is a preparation made from *Clostridium welchii* toxin which contains only traces of hyaluronidase.

All tissues were fixed by freezing-drying. The blocks were embedded in paraffin and cut at six micra in most cases. The sections were deparaffinized in petroleum ether and denatured in ethyl alcohol before being stained. When phosphate-carbonate was demonstrated, sections were made at sixteen micra and deparaffinized in anhydrous petroleum ether just before treatment with the silver reagent.

AR, artefact; *C*, central zone; *CO*, collar; *F*, fibroblast; *I*, intermediate zone; *P*, peripheral zone; *PE*, perichondrium.

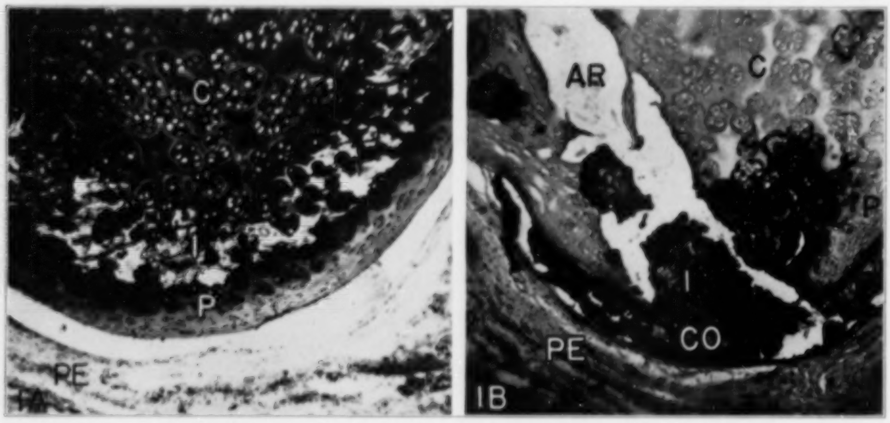

FIG. 1-A FIG. 1-B

Sections (× 50) stained with hematoxylin and eosin to show morphological details.

Fig. 1-A: Non-boiled autograft, 270 days after implantation, showing chondrocyte groups in the central zone embedded in an optically homogeneous basophilic matrix and surrounded by unstained capsules. The matrix bordering the intermediate zone is intensely basophilic. The matrix between the two borders is for the most part unstained. The cells in the peripheral zone show transition from spindle to oval shape.

Fig. 1-B: Boiled autocartilage, 270 days after implantation. Only remnants of cells remain. The central zone stains faintly basophilic. The collar stains intensely basophilic. The intermediate zone is absent.

OBSERVATIONS

A. *Histological Characteristics of Costal Cartilage and Implants*

Cross sections of costal cartilage were studied in order to compare the morphological and histochemical characteristics in (1) fresh and boiled cartilage, and (2) implanted boiled and non-boiled cartilage (Figs. 1-A and 1-B).

An arbitrary division of the cartilage into central, intermediate, and peripheral zones was made. The central zone showed closely packed polyhedral chondrocytes in younger cartilage and oval hypertrophic chondrocytes in older cartilage. The nuclei of the cells were basophilic, oval, and reticulated. The cytoplasm of the chondrocytes was clear. The cell groups were surrounded by a refractile region, the cartilage capsule or pericellular halo. An intensely basophilic matrix surrounded the capsules. The rest of the matrix presented lesser degrees of basophilia.

The chondrocyte groups in the intermediate zone were usually widely separated, giving the appearance of "cell islands". In the regions of the internal and external borders of this zone, the matrix was characterized by clear, finger-like processes which partially or completely enveloped cell groups. The stained matrix in the internal and external borders of this zone surrounding the finger-like processes was intensely basophilic. The costal cartilage removed from animals sixty-three days of age usually did not present this zone, but it was differentiated at seventy-seven days. In autografts, it was differentiated at fourteen days after implantation (or seventy-seven days of age) and in boiled autocartilage implants it was usually absent.

The peripheral zone was subdivided into the oval-cell and flat-cell layers. The chondrocytes presented transitional morphological characteristics between the hypertrophic cells in the central zone and the spindle-shaped cells of the flat-cell layer. The cytoplasm

TABLE I

SUMMARY OF THE HISTOCHEMICAL REACTIONS FOR CARBOHYDRATE-PROTEIN COMPLEXES, METACHROMASIA, AND INTRACELLULAR GLYCOGEN IN COSTAL CARTILAGE AND AUTOCARTILAGE IMPLANTS

Costal Cartilage				Autocartilage Implants						
Non-Boiled				Non-Boiled			Boiled			
Age of Animal at Death (*Days*)	Carbohydrate-Protein Complexes *	Metachromasia*	Glycogen **	Duration of Implantation (*Days*)	Carbohydrate-Protein Complexes *	Metachromasia *	Glycogen **	Carbohydrate-Protein Complexes *	Metachromasia *	Glycogen **
42	+++	++	+++							
63	+++		+++							
77	+++	+++	+++	14	+++	+++	+++	+++	+++	++
93	+++		++	30	+++		+++	+++		+
123	+++	++	++	60	+++	++	++	++	+++	+
183	++	++	++	120	++	+++	+	++	++	0
243	++	++	++	180	++	+++	++	+	+	0
333	++	++	+	270	++	++	+	+	+	0

* Plus signs indicate intensity of staining reaction.

** Estimated concentrations of intracellular glycogen from abundant (+++) to absent (0) as visualized by the periodic-acid-leukofuchsin reagent.

of most cells was clear; however, a few were basophilic. External to the flat-cell layer was the perichondrium composed of dense connective tissue, blood vessels, and nerves.

The costal cartilage from an animal sixty-three days of age placed in boiling distilled water for at least fifteen minutes showed chondrocytes in the central zone with hyperchromatic nuclei. There was a condensation or shrinkage of the matrix, especially in the peripheral zone. This was confirmed by the reduction in cross-sectional size when compared with a section taken from the non-boiled half of the original costal cartilage.

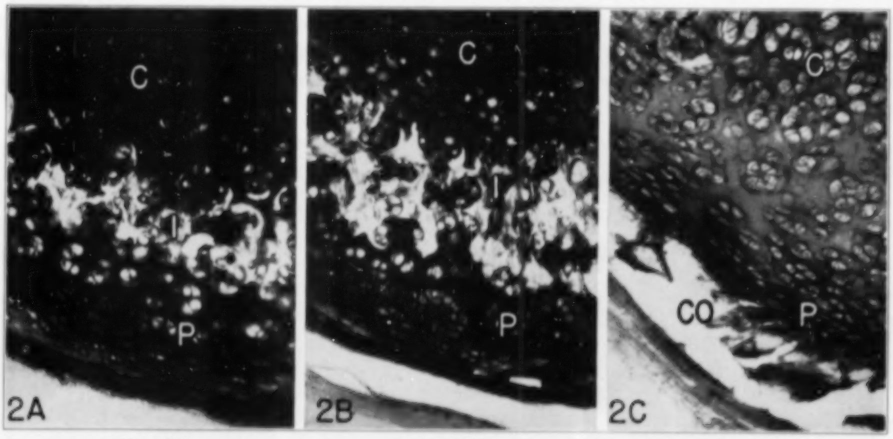

FIG. 2-A FIG. 2-B FIG. 2-C

Sections (× 100) stained with the periodic-acid-Schiff reagents.

Fig. 2-A: Costal cartilage from an animal 333 days old. The matrix, with the exception of the intermediate zone, is intensely stained and has a fairly homogeneous appearance.

Fig. 2-B: Non-boiled cartilage 270 days after implantation. The staining reaction is essentially the same as that in Fig. 2-A.

Fig. 2-C: Boiled autocartilage 270 days after implantation. The fibrous nature of the matrix in the central zone is exposed, presumably by dissolution of the ground substance. The most intensely stained area lies adjacent to the collar, of which only remnants are preserved because of difficulty in sectioning. On the whole this section is not as intensely stained as those shown in Figs. 2-A and 2-B.

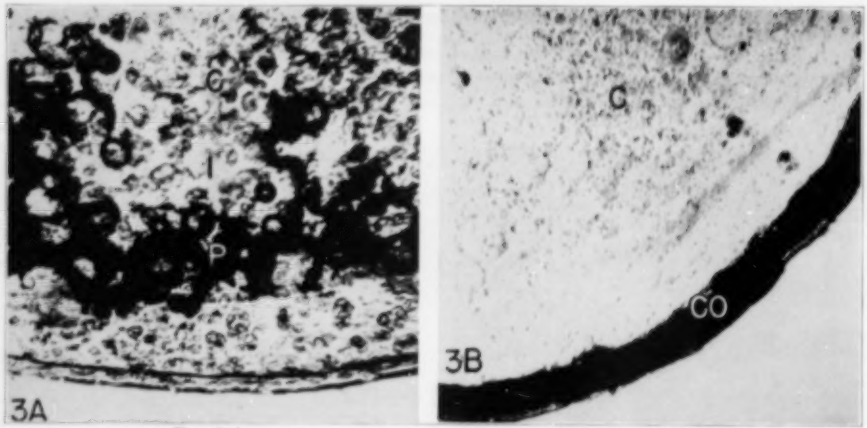

FIG. 3-A FIG. 3-B

Sections (× 100) stained for phosphate-carbonate according to the method of Gersh.

Fig. 3-A: Non-boiled fourteen-day autograft. Phosphate-carbonate deposits in and around the intermediate zone appear black.

Fig. 3-B: Boiled fourteen-day autocartilage implant. The phosphate-carbonate deposits are primarily in the collar.

B. *Carbohydrate-Protein Complexes in the Ground Substance*

1. *Zonal Localization in Costal Cartilage and Implants:*

From the forty-second to the sixty-third day of animal life, zonal staining in fresh costal cartilage was greatest in the central zone, with gradually diminishing intensity of staining toward the peripheral zone (Table I). The intermediate zone was not present and the flat-cell layer of the peripheral zone was not stained. With the differentiation of the intermediate zone in costal cartilage from animals seventy-seven days and older and autografts fourteen days and older (Figs. 2-A and 2-B), staining reactivity in the various zones was in the following order of diminishing intensity: the internal and external borders of the intermediate zone, the central zone, the oval-cell layer of the peripheral zone. The matrix of the intermediate zone proper showed many unstained areas. The most intense staining was seen in the pericapsular matrix, with lesser degrees of reactivity in the intervening matrix. The pericellular halos did not stain.

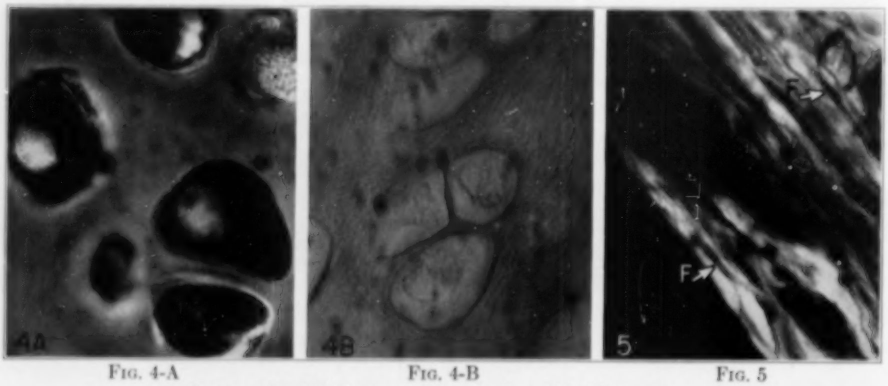

FIG. 4-A FIG. 4-B FIG. 5

Sections (× 725) stained with periodic-acid-Schiff reagents.

Fig. 4-A: Chondrocytes showing intracellular aggregates of glycogen in a 270-day non-boiled autograft. The nuclei are unstained. The homogeneous character of the matrix is evident.

Fig. 4-B: Boiled autocartilage, 270 days after implantation, showing fibrillar character of the matrix and absence of intracellular glycogen.

Fig. 5: Resorption in the peripheral area of a sixty-day non-boiled autograft. The fibers are exposed after dissolution of the ground substance. Fibroblasts containing granules of glycoprotein are shown.

Boiled autocartilage implants fourteen days and older (Figs. 2-C and 4-B) appeared to stain evenly throughout the matrix. No marked zonal staining was seen, although the portion just internal to the collar, an unstained C-shaped structure in the peripheral zone, stained deeper. Boiling, in general, appeared to increase the intensity of staining.

2. *Variations with Age:*

Costal cartilage showed the same intensity of staining with the periodic-acid-leukofuchsin reagent (red) from forty-two to 123 days of animal life (Table I). A slight decrease was seen at 183 days of animal life, after which there was no change until 333 days. Costal cartilage, from animals forty-two and sixty-three days of age, when boiled, stained more intensely than similar pieces of cartilage which had not been treated.

Autografts showed an almost identical variation in the intensity of staining with age as their controls, the sixth costal cartilage from the host animals (Figs. 2-A and 2-B). Boiled autocartilage fourteen days after implantation appeared to stain red with the same intensity as the autografts of equivalent age and the costal cartilages of the host animals. Thereafter, the boiled autocartilage showed a rapid decrease in staining intensity until, at 270 days after implantation, only a pink stain was seen in the tissues (Fig. 2-C). With high magnifications the fibrils of the matrix appeared unmasked (Figs. 4-A and 4-B). Free aldehydes and glycolipids which could give interfering positive Hotchkiss reactions were minimal or absent in either costal cartilages or implants.

In general the intensity of the metachromasia in the various zones in fresh costal cartilage, autografts, and boiled autocartilage implants paralleled the staining intensity with the periodic-acid-Schiff reagents.

C. *The Effect of Some Mucolytic Enzymes on Cartilage Ground Substance*

1. *Bovine Testicular Hyaluronidase:*

A slight inhibition in the development of metachromasia in all zones was observed when costal cartilage, autografts, and boiled autocartilage implants of the ages studied were incubated with bovine testicular hyaluronidase for one hour and then stained with toluidine blue. A similar effect was not observed in sections treated with the buffer alone. This result was not related to the previous treatment or to age of the cartilage.

2. *Collagenase:*

The tissues studied were affected by collagenase. The ground substance and fibers were lost from the sections following the action of the enzyme. Boiled cartilage incubated for twenty-four-hour periods was almost completely dissolved. Shorter periods of incubation resulted in partial solution of the ground substance, leaving fibers of the matrix exposed. The central and peripheral zones were equally involved, while the intermediate zone was resistant. In general the solution of the cartilage by collagenase was in the following order of increasing susceptibility: costal cartilage, autografts, and boiled autocartilage implants.

D. *Comparison of the Connective-Tissue Cellular Reactions*

Generally, there was no infiltration of connective-tissue cells into the matrix of costal cartilage of animals forty-two to 333 days of age. However, a reaction was observed about the implants. The connective-tissue cellular reaction was somewhat more marked around the autografts than in the boiled autocartilage from the fourteenth to the thirtieth day after implantation. Connective-tissue cells resembling fibroblasts were seen in the peripheral areas of the autografts, where the ground substance had been lost and the fibers had been exposed (Fig. 5). A gradual decrease in the number of connective-tissue cells surrounding the autografts was seen from sixty to 270 days after transplantation.

In boiled autocartilage implants, the zone of resorption was just peripheral to the collar. A moderate number of fibroblasts were seen surrounding boiled autocartilage at fourteen and thirty days after implantation. These fibroblasts lay between the cartilage fibers which ran parallel to the periphery. Dissolution of the ground substance was seen in the immediate area of the fibroblasts. Many of the cells, during the active phase of resorption, showed Hotchkiss-positive material in their cytoplasm which was not removed by exposure to amylase. Phagocytic cells showed brown pigments in their cytoplasm (in hematoxylin and eosin preparations), presumably reduction products of hemoglobin. From sixty to 180 days after implantation, considerably more connective-tissue cells were seen surrounding boiled autocartilage implants than were seen around the autografts of equivalent age.

E. *Intracellular Glycogen*

1. *Costal Cartilage:*

At sixty-three days of age, the concentration of glycogen in the costal cartilage was as follows, in decreasing amounts: cells of the central zone, cells of the intermediate zone (when the zone was differentiated), and the oval-cell layer of the peripheral zone. Glycogen could not be demonstrated in the flat-cell layer of the peripheral zone or in the perichondrial cells. Glycogen appeared in the cytoplasm of chondrocytes of costal cartilage as finely granulated aggregates. The nucleus of the cell did not show this substance. Costal cartilage in animals forty-two to seventy-seven days of age showed a high concentration of glycogen. Thereafter, a gradual decline in total concentration of glycogen was observed to the age of 333 days (Table I).

Boiled costal cartilage from an animal sixty-three days of age showed numerous cells in the central zone with significantly reduced amounts of glycogen. A homogeneous, thin rim of glycogen remained, while rich granular aggregates were seen in the cytoplasm of corresponding cells of the non-boiled specimen.

2. *Implants:*

Autografts showed essentially the same concentration and variation of glycogen with age as the costal cartilage (Fig. 4-A). From the peak concentration at fourteen days after implantation, there was a gradual decrease until 270 days after implantation, when only a small amount of glycogen remained (Table I).

Boiled autocartilage showed rapid glycogen loss from the fourteenth day until after sixty days of implantation, when only a few cells showed some coarse granules of glycogen. Glycogen was completely absent from all boiled implants (Fig. 4-B and Table I) of 120 days' duration and longer.

F. *Phosphate or Carbonate, or Both*

The observations for non-boiled costal cartilage and autografts will be considered together, as the results appeared to be almost identical in all age groups. Areas staining black or dark brown were assumed to contain phosphate or carbonate or both, presumably as calcium salts.

Costal cartilage from an animal sixty-three days of age showed a few areas in which the matrix was light brown, a coloration which may be due to chlorides or proteins. Costal cartilage from an animal seventy-seven days old and its fourteen-day autograft showed homogeneous black-staining deposits of phosphate-carbonate in the intermediate zone, which did not stain with hematoxylin and eosin (Fig. 3-A). The black-staining matrix showed finger-like projections in the external and internal borders, partly or completely enclosing cell groups. The matrix of the central and peripheral zones was light brown, with some finely dispersed black granules. There was no increase either in the width or in the density of the phosphate-carbonate deposits in the intermediate zone of costal cartilage from animals 123 to 333 days old or autografts of thirty to 270 days.

Boiled costal cartilage from an animal sixty-three days of age showed a dark brown matrix, with black deposits in the cytoplasm of chondrocytes of the central and peripheral zones. The pericellular halos were light brown. An intermediate zone was not present. Diffusion effects and solution of salts occurred in these boiled preparations.

Boiled autocartilage fourteen days after implantation presented a solid, black-staining phosphate-carbonate layer in the peripheral structure earlier referred to as the "collar" (Fig. 3-B). Granules of phosphate-carbonate were seen in the neighboring chondrocytes and matrix. The color in the rest of the matrix was light brown. After the thirtieth day of implantation, the thickness of the collar appeared to increase slightly up to 270 days.

For purposes of control, cartilage sections were treated with a solution of 5 per cent. nitric acid for ten minutes. These preparations did not stain for phosphate-carbonate.

DISCUSSION

The ground substance and fibers of costal cartilage and autocartilage implants are gradually altered with increase in age. These changes were seen in sections which were stained to visualize the carbohydrate-protein complexes, in which the decrease in stainability of the ground substance was interpreted as evidence of its disaggregation [5]. Some additional changes would be expected in the autocartilage implants as a result of transfer to a new site, but a more advanced reaction might be expected in homocartilage implants because of transfer to a new site in a different host. While in the costal cartilage and nonboiled autografts the dissolution of the matrix proceeded very slowly, previously boiled cartilage dissolved much more rapidly. The preliminary depolymerization of the boiled cartilage matrix also increased its susceptibility *in vitro* to the action of certain enzymes, notably collagenase.

The profound effect, *in vitro*, of some mucolytic enzymes on boiled cartilage implants suggested that the *in vivo* dissolution of these implants might be due to similar substances. This would be consistent with a theory that the cells of the connective tissue may liberate enzymes which dissolve ground substance and lead to dissolution of the collagen fibers [5]. These components of boiled cartilage might be affected in like manner. In surgical procedures in which permanent reconstruction is a requisite it would seem undesirable, therefore, to use cartilage which has been boiled or degraded in any way.

The pronounced change in stainability of the peripheral zone of boiled implants, interpreted as evidence of the first stages of depolymerization, was associated with the deposition of calcium phosphate or carbonate, or both. Such mineralization of boiled cartilage implants was also reported by Wells in his early studies. While calcium is present throughout the matrix in protein-bound and ionic states [3], the insoluble apatite appears to form in association with changes in the carbohydrate-protein complexes of ground substance. This is in agreement with suggestions that the calcification of bone and of cartilage are influenced by the physicochemical state of the matrix [1,3,5,6,10]. Evidence of calcification in an implant thus may be taken as indicating an advanced stage in its dissolution.

In general, the fate of the implant is determined by its inherent physicochemical properties and by the reactions in the connective tissue of the host. Such factors as the immune reaction, age, and hormone activity may exert important modifying influences.

Evidence for continued metabolic activity in fresh cartilage transplants has been provided in manometric studies showing anaerobic utilization of glucose [8]. From the histochemical studies, too, in which the persistence of intracellular glycogen in the chondrocytes of autografts was shown, it may be inferred that the cells were maintaining some metabolic activity. It is of interest to note that these histochemical findings were similar to those in costal cartilage of a comparable age (Table I).

SUMMARY AND CONCLUSIONS

The behavior of cartilage transplants and the cellular reaction in the surrounding connective tissue have been studied in rabbits. Costal cartilage was used as a control.

Histochemical methods, together with freezing-drying fixation, were used to visualize some tissue components of interest. These included the carbohydrate-protein complexes of the ground substance, inorganic phosphate-carbonate, and intracellular glycogen. Dissolution of the mucoprotein ground substance was observed on the periphery of autografts sixty days after implantation and of costal cartilage of comparable age. In boiled autocartilage implants, a more general and extensive dissolution occurred and this began much earlier. In these instances the changes in the matrix were accompanied by deposition of phosphate-carbonate, presumably as the calcium salt. *In vitro* experiments in which a bacterial collagenase was used resulted in striking disintegration of boiled cartilage and somewhat lesser changes in non-boiled autocartilage grafts and costal cartilage. In a like manner enzymatic activity by connective-tissue cells could lead to changes in the matrix of implants. The fate of cartilage implants appears to be determined by their inherent physicochemical characteristics and by the connective-tissue reaction which is provoked in the host. Cells of the boiled cartilage implants lost their glycogen early and resynthesis was impossible. In the autografts, evidence for sustained metabolic activity comparable with that in costal cartilage was deduced from the continued presence of intracellular glycogen.

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COMPLICATIONS OF JUDET ARTHROPLASTY DUE TO FOREIGN-BODY REACTION TO NYLON PROSTHESES

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Since the original report by Robert and Jean Judet [2] on femoral-head replacement arthroplasty, this procedure has been widely accepted and performed in this country. As the procedure has gained wider acceptance and has been more frequently performed, with varying techniques, by an increasing number of surgeons, a number of complications have been encountered. This paper is presented in order to emphasize one of the possible complications which should be avoided.

In the early stages of performing the Judet arthroplasty, the technique and materials recommended by the Judets were employed. Many surgeons, however, hesitated to use the acrylic prosthesis, since it could not be boiled or autoclaved and its sterility depended upon soaking in antiseptic solution. For this reason, many surgeons turned to the use of a nylon prosthesis. This substance was reported to be relatively inert in the body, retaining the elasticity of plastic, which was considered to be an advantage, and still it could be boiled or autoclaved.

At first, the use of a nylon prosthesis seemed to be ideal, but subsequent follow-up has shown that foreign-body reaction to the nylon with disagreeable sequelae has developed in a significant proportion of the patients. In six of the patients upon whom we had performed arthroplasty with a nylon prosthesis, and in one patient in whom the same procedure had been performed elsewhere, we have encountered just such an adverse reaction to the nylon. In four of these patients, arthroplasty had been performed because of malum coxae, in two because of an ununited fracture of the femoral neck with a non-viable head, and in one patient arthroplasty had been performed as primary treatment for a high, subcapital femoral-neck fracture. Following surgery, with insertion of the nylon prosthesis, all of the patients had done well initially and during the first several months of convalescence. Then each patient began to have pain and progressive limitation of movement in the hip. The roent-

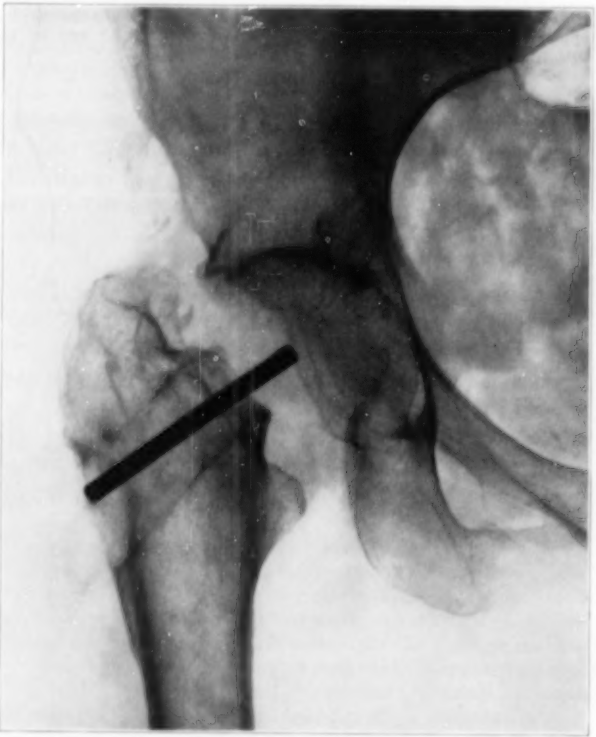

FIG. 1

Case 2. Roentgenogram showing osteoporosis and absorption about the stem of the prosthesis. Note the obliquity of the reinforcing rod in the stem of the prosthesis.

genograms at first had shown no signs of bone disturbance, but, as the reaction continued and became more severe, a mottled destruction had become evident in the remaining portion of the neck of the femur; absorption about the stem of the prosthesis (Fig. 1) and osteoporosis about the acetabulum had been noted. The more prolonged and severe the symptoms, the more pronounced were the roentgenographic findings.

At re-operation, the findings were rather uniform. In none of the patients was there any evidence of infection. The joint capsule was usually only slightly thickened. The most dramatic changes were in the synovial membrane; in all except one patient, the hypertrophic, yellow, caseous-appearing, villous synovial membrane was present. There were varying amounts of bone absorption and destruction, primarily in the neck of the femur. The head of the prosthesis was roughened, non-glistening, and worn and flattened on its superior surface (Figs. 2-A and 2-B). As would be expected, the amount of roughening and flattening of the head of the prosthesis and the associated synovitis and bone absorption seemed to be in direct relation to the length of time the prosthesis had been in place and the use the individual had given it. The one patient whose prosthesis showed little roughening and in whom there was little synovial reaction was the patient in whom the arthroplasty had been done as primary treatment for a subcapital fracture in the neck of the femur. In this case, the patient had been unwilling to bear much weight on the involved extremity, or even to be up and about with crutches to any degree.

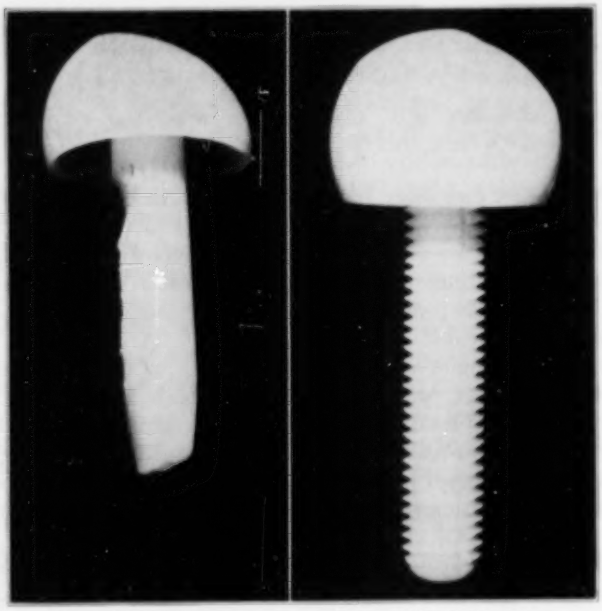

FIG. 2-A FIG. 2-B

Two of the nylon prostheses removed in this series. Note the varying amount of erosion on the superior surface of the head and on the surface of the stem just beneath the head.

Dr. C. T. Ashworth, pathologist at Harris Hospital, Fort Worth, Texas, has given the following description of the microscopic pathology in two typical cases:

CASE 1 (Fig. 3): "Microscopic examination of tissue from the synovial lining reveals an extensive inflammatory process. There are foci of necrotic material having an eosinophilic, granular structure in which a few indefinite particles are found. Also, deposits of calcium are noted here, occurring as rather heavy clumps. Around the foci of necrotic material, there is a granulomatous reaction consisting of numerous large macrophages which are somewhat foamy in appearance. A few multinucleated giant cells of the foreign-body type are present and rare lymphocytes and plasma cells are found. There is a proliferation of fibroblasts among the infiltrating macrophages here.

"Examination under polarized light reveals highly refractile bodies of small sizes. These particles are estimated to measure from five to ten micra.

"*Comment:* The reaction, as we see it in this case, is an inflammatory one associated with focal necrosis and granulomatous type of response. Since we are able to find refractile bodies visible under polarized light in the necrotic areas, it seems probable that these particles are producing some type of local tissue injury resulting in necrosis and followed by a foreign-body reaction."

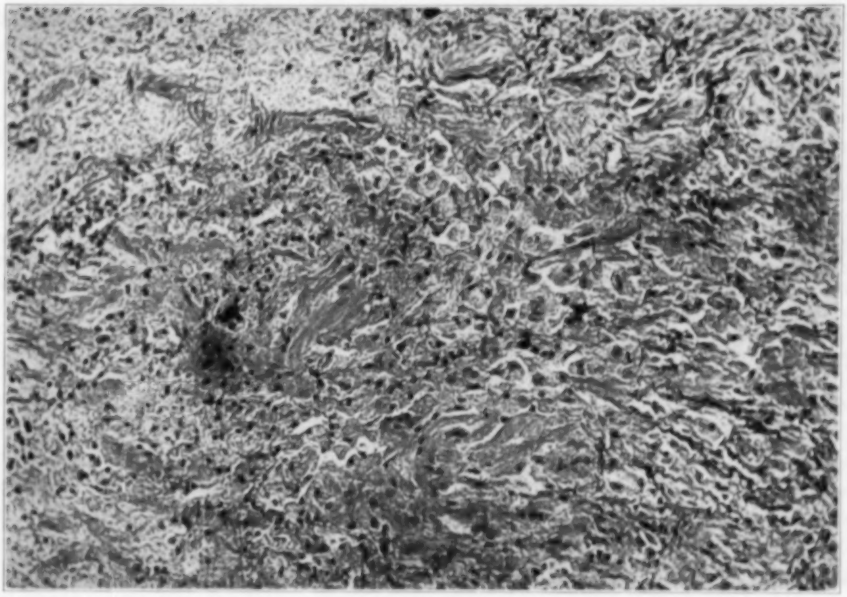

FIG. 3

Photomicrograph (× 160) of tissue removed from hip in Case 1. (See report of Case 1, page 1178.)

CASE 2 (Fig. 4): "Microscopic examination of blocks from the synovial lining show a great degree of hypertrophy of the synovial folds, which are club-shaped. Some of them are devoid of any synovial lining, but others are lined by several layers of synoviothelial cells which are moderately swollen. In several areas, fibrinous deposits are found over the surfaces of these synovial projections. There is an overgrowth of fibroblast-like cells in the stroma of the villi associated with new capillary formation and scanty diffuse lymphocytic infiltration. Among these hypertrophied synovial projections, there are occasional accumula-

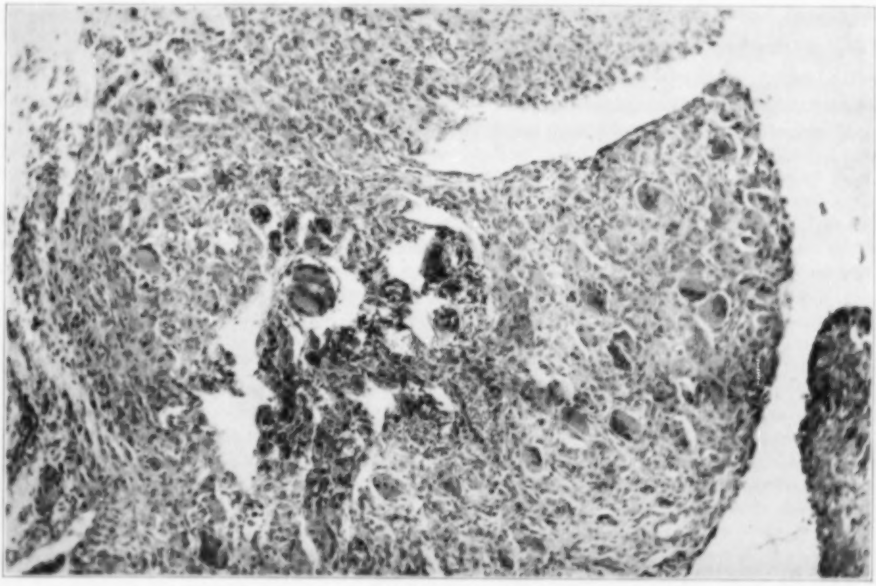

FIG. 4

Photomicrograph (× 200) of tissue removed from hip in Case 2.

tions of granulation tissue characterized by an extensive production of multinucleated, foreign-body giant cells. These have abundant pale-staining pink cytoplasm, although some of them are slightly foamy, and a few contain brown granular pigment of hematogenous type. Also, a few foamy macrophages are noted in these areas. No definite necrotic tissue is identified.

"As these areas of foreign-body reaction are examined under polarized light, they are found to contain innumerable foreign particles measuring approximately up to ten micra, but most of them being only three or four micra in diameter. These refractile particles are found to be located partly in the giant cells and partly between them.

"*Comment:* In this case, we observe evidence of marked synovial hypertrophy and mild chronic inflammation. Actually, in the synovial projections, there is no evidence of the refractile nylon. However, in addition, there are foci where a foreign-body type reaction has been produced and in these areas the refractile particles, as seen under polarized light, are very abundant, apparently representing the inciting agent leading to the foreign-body reaction."

In all of the patients, further surgery has been performed in an attempt to relieve their condition. In two of the patients, there had not been much bone destruction in the femoral neck and, after removal of the nylon Judet prosthesis, a stainless-steel prosthesis of the same size and shape was inserted. In four of the patients, an intramedullary stem prosthesis of the so-called Minneapolis type was used in the secondary reconstruction and, in one patient, an F. R. Thompson prosthesis was inserted after removal of the nylon femoral head. None of these patients has been followed long enough for us to give a final report of the secondary procedure, but all of the patients seem to be following a much better course than they did with the original nylon prosthesis. The patients in whom a Minneapolis or F. R. Thompson type of intramedullary prosthesis was used seem to have regained function and to have had an alleviation of pain much more quickly and better than the ones in whom the stainless-steel Judet replacement was employed. This report is being submitted without adequate follow-up of the last surgical procedure, since its primary purpose is to discourage the further use of nylon as a substance for prosthesis in hip arthroplasty.

In considering the reason for the delayed reaction to the nylon in these cases, we think that our findings corroborate a theory suggested by McKeever [3]. He feels that the actual amount of sensitivity and reaction to the nylon in these cases may be minimal, so that, if there were no more nylon surface exposed than the original surface of the prosthesis, very little reaction would be encountered. However, as the patient begins weight-bearing, microscopic portions of the nylon are progressively worn off the prosthesis and remain in the joint, thus causing a tremendous increase in the surface area of nylon exposed to the tissue, and, consequently, a great increase in the amount of sensitivity reaction.

CASE REPORTS

CASE 1. H. A. M., aged sixty-four, white male, was first seen in July 1951, with malum coxae of the right hip, resulting from trauma to the hip ten years previously. For two years prior to the time this patient was first seen, he had been having progressive pain, stiffness, and disability in the right hip. Roentgenograms revealed a marked narrowing of the right hip joint space, with adjacent flattening, sclerosis, and lipping at the joint margins. A Judet arthroplasty with a nylon prosthesis was performed elsewhere in April 1952. Following the surgery, the patient progressed very well and was able to walk with a moderate limp and minimal discomfort. After four or five months, he began to have pain in the hip, which at first was relieved with the use of a brand of phenylbutazone, but which later became more persistent and disabling. By July 1953, this patient was ambulatory only by means of crutches; he could not bear weight on the right leg, and there was severe pain on any movement of the right hip. Examination at that time revealed a definite telescoping sensation and instability in the right hip. An operation was performed on July 30, 1953, revealing marked yellow, caseous villous synovitis and marked erosion and destruction of the femoral neck. There was extensive absorption about the stem of the prosthesis, which was completely loose in the femur. The prosthesis was removed, all of the synovial membrane was excised, and a Minneapolis type of prosthesis was inserted. Full weight-bearing was not allowed for six months. The patient now walks with a moderate limp, uses a cane in getting about, and has minimal discomfort on prolonged activity.

CASE 2. W. L. D., aged fifty-eight, white female, was first seen on July 14, 1952, with an ununited fracture of the neck of the left femur. The initial injury had occurred February 1, 1951, and closed reduction and pinning had been performed elsewhere at that time. The pin had been removed in April 1952. At the time of examination, July 14, 1952, the patient walked with a marked limp on the left, used a cane, and complained of severe pain and disability. Roentgenograms revealed an ununited subcapital fracture of the neck of the left femur with aseptic necrosis of the head of the femur. On August 12, 1952, the Judet arthroplasty was performed, the nylon prosthesis having been made witb a three-eighth-inch extension to compensate for previous absorption of the femoral neck. This patient's postoperative course was very satisfactory; by October she had a full range of motion in the left hip, was able to walk very well with a cane, and without the cane had only a moderate gluteal limp on the left side. In December 1952, four months after operation, she began to have discomfort in the hip and was instructed to take phenylbutazone. This seemed to relieve the discomfort satisfactorily at first, but later she began to have an increasing amount of discomfort, even though taking phenylbutazone. By February 1954, progressive pain and a limp had developed in the left hip, although the patient had retained an excellent range of motion in the hip and had very good muscle power. Roentgenograms made at this time showed a definite erosion about the stem of the prosthesis which had not been visualized on previous roentgenograms. On March 9, 1954, the nylon prosthesis was removed. A moderate amount of roughening and flattening of the prosthesis was found, and an associated moderate yellowish synovitis was encountered (Fig. 4). A synovectomy of the hip joint was performed, after which an F. R. Thompson type of prosthesis was inserted. The patient is now ambulatory with a cane.

Case 3. S. H. W., aged sixty-three, white female, was first seen on September 8, 1952, and gave a history of progressive pain in both hips for seven years. Examination revealed marked limitation of motion in both hips, associated with pain and increasing crepitation. Roentgenograms revealed typical findings of bilateral malum coxae. On November 3, 1952, Judet reconstruction with a nylon prosthesis was performed on the right hip. Two months from the date of surgery, the patient demonstrated a fairly good range of flexion and full extension in the right hip and was able to walk, using only one crutch. Four months from the date of the operation, she began to have limitation of movement in the hip and increasing pain for which phenylbutazone was prescribed. At first, the phenylbutazone gave excellent relief of pain, but after several months the discomfort and disability had increased. Another operation was performed on August 18, 1953. When the right hip was opened, the patient was found to have a typical roughening and flattening of the prosthesis and an extensive yellow, caseous, villous synovitis, as had been noted in previous cases. The prosthesis was removed; a partial synovectomy was performed; and a stainless-steel Judet prosthesis was inserted. The patient still has moderate stiffness in the hip and pain on walking, necessitating the use of one crutch.

Case 4. T. L. W., aged eighteen, white male. A Judet arthroplasty with a nylon prosthesis was performed on the patient's left hip on November 20, 1952, for malum coxae resulting from old Legg-Perthes disease. Prior to surgery, he had walked with a marked limp, had had pain on walking, and had limitation of motion from 180 to 120 degrees in the left hip. Two months following the operation, the patient stated that he walked better than he ever had before. He was able to walk well with one crutch and had only a moderate limp when walking without crutches. The range of hip flexion was from 180 to 90 degrees; abduction was 75 per cent. of normal; and there was full adduction. The patient stated that he had no pain at that time. Eight months after surgery, he started having pain in the left hip, which gradually increased. As the pain increased, he started limping more, and it was finally necessary to restrict his activity. The pain became rapidly worse and, on October 2, 1953, another operation was performed on the left hip. At the time of surgery, a yellowish, villous synovitis was found. There was only a slight amount of erosion of the head of the prosthesis, but the stem was found to be fractured. Following removal of the prosthesis and a partial synovectomy, a Minneapolis type of prosthesis with a stainless-steel head was inserted. When last seen in March 1954, this patient was walking with one crutch and had only minimal pain in the hip.

Case 5. W. J. S., aged thirty-six, white female, was first seen on August 4, 1952. The case history suggested that an infection in the hip in infancy had resulted in malum coxae of the right hip. The patient had had progressive pain, a limp, and disability for six months prior to the time of examination. Roentgenograms revealed distortion of the head and neck of the right femur with roughening of the head, loss of joint space in the right hip, and adjacent bone sclerosis. On August 9, 1952, a reconstruction of the right hip was performed with a nylon Judet prosthesis. Four months following surgery, roentgenograms revealed excellent position of the prosthesis, with no visible evidence of reaction or erosion. The patient was getting about satisfactorily with minimal discomfort in the hip, but at that time she was still using two crutches with only partial weight-bearing. Seven months following surgery, the patient began to have increasing pain and disability in the hip. September 15, 1953, another operation was performed. Exposure of the hip joint revealed a typical yellow, caseous synovitis with very little capsular thickening. Moderate erosion and roughening of the head of the prosthesis were noted and, in addition, a fracture of the stem of the prosthesis just beneath the head. After removal of the nylon prosthesis, a stainless-steel prosthesis of similar size and shape was inserted. Six months following the last operation, this patient was still having pain in the hip on weight-bearing, necessitating the use of one crutch for walking about, and there was still a considerable limitation in range of motion.

CASE 6. R. W., aged forty-five, white male, was seen in September 1947, after he had suffered a fracture of the neck of the left femur when he fell from a scaffold. Closed reduction and Smith-Petersen nailing were performed at that time. Non-union resulted and, on April 22, 1948, a Dickson osteotomy was performed. Following this, the patient obtained union. Insurance settlement was made in October 1948, and the patient was not seen again until 1952. On May 21, 1952, he reported to the office because of a progressive limp and pain in the hip. Roentgenograms made at that time revealed that the fracture in the neck of the femur had healed solidly but showed an aseptic necrosis with collapse of the femoral head and a distorted acetabulum with arthritic changes. On July 21, 1952, a reconstruction of the left hip was performed with insertion of a nylon Judet prosthesis. Three months following the operation, the patient was able to walk with one crutch and did not complain of pain in his hip. Six months following surgery, he began having intermittent pain in the left hip, which gradually increased. Nine months after the operation, there was a sudden marked increase in the amount of discomfort in the hip, and roentgenographic examination at that time revealed a fracture of the stem of the prosthesis. On July 21, 1953, another operation was performed on the left hip. The nylon prosthesis was found to be partially worn and roughened, and the stem was fractured. Moderate yellowish synovitis was found. The prosthesis was removed and a Minneapolis type of prosthesis was inserted. Eight months following this operation, the patient could walk about, using a cane. He still had considerable muscle weakness about the left hip and complained of pain in the hip on overactivity.

CASE 7. A. R., aged sixty-two, white female, was first seen on January 1, 1953, with a subcapital fracture of the neck of the right femur. On the following day, a nylon Judet prosthesis was inserted. The patient was much more feeble than her age would indicate and had great difficulty in getting out of a wheel chair and in using crutches. She continued to complain of pain in the right hip, weakness, and inability to use the right leg. One year after her initial operation, she was able to walk about with only one crutch, although, actually, she was not up and about very much. She still complained of pain in the right hip, and roentgenograms revealed some absorption about the stem of the prosthesis. On February 23, 1954, the right hip was re-opened. The nylon prosthesis showed very little evidence of erosion, and there was minimal synovial reaction. The prosthesis was removed and a Minneapolis type of prosthesis was inserted. During this procedure, a subtrochanteric spiral fracture occurred, due to over-zealous handling of the osteoporotic femur. The stem of the Minneapolis prosthesis, however, served as a very satisfactory intramedullary pin, holding the fragments in excellent position. This patient is now up and about in a wheel chair and states that she has much less discomfort in her hip than she had had on similar activity prior to the second operation.

SUMMARY

It is felt advisable to refrain from using nylon Judet femoral heads for replacement arthroplasty.

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2. JUDET, JEAN, and JUDET, ROBERT: The Use of an Artificial Femoral Head for Arthroplasty of the Hip Joint. J. Bone and Joint Surg., **32-B:** 166–173, May 1950.
3. MCKEEVER, DUNCAN: Discussion of [1].

TRANSPLANTATION OF THE POSTERIOR TIBIAL TENDON

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For twenty-five years or more at the New York Orthopaedic Hospital, various types of operative procedures have been used for transfer of tendons to the dorsum of the foot. Several of these have proved to be of definite value and are now frequently employed. Transplantation of the extensor hallucis longus to the first metatarsal; of the extensor digitorum communis to the mid-foot or metatarsal bones; of the tibialis anterior to a more lateral position; and of the peronaeus longus or brevis, or both, to one of the cuneiforms, have all given satisfactory results in properly selected cases.

Until September 1951, the use of the posterior tibial muscle as an active force for dorsiflexion of the foot had received little attention. It was frequently observed to be a deforming factor, either producing or accentuating a varus position of the foot; and in many instances the tendon was severed or lengthened to overcome the deformity. Excellent reviews of tendon transplantations by Peabody and by Carpenter make no mention of the use of the posterior tibial tendon as a transplant for dorsiflexion of the foot, although Peabody describes sectioning it as "security against varus imbalance". In cases of paralytic equinovarus, Goldner and Irwin have stressed the importance of either sectioning or transplanting the posterior tibial tendon.

Ober wrote: "In cases of equino varus where there is normal power in the gastrocnemius and the posterior tibial muscles, the latter is the chief deforming factor. Tenotomy of the posterior tibial and correction of the varus deformity relieve the situation in part, but it is difficult to prevent the recurrence of equinus and it seems an unwarranted waste to throw away the power of a good muscle." He described transplantation of the posterior tibial tendon around the medial border of the tibia to the dorsum of the foot. Mayer [7], however, stated that this procedure is not physiological because of the indirect pull of the muscle and tendon. This method of using the posterior tibial muscle has not been widely used because the results were not encouraging.

During the past two and one-half years at this Hospital there has been considerable interest in the method of transplanting the posterior tibial muscle and tendon through the interosseous membrane of the tibia and fibula to the dorsum of the foot. This method is more reasonable because a direct pull of the transplanted tendon is obtained. Although it is known that this procedure has been performed in other hospitals, a careful search of the literature has failed to reveal a report of the operative technique. In an article published in 1937, Mayer [6] stated that the operation had been performed by Putti. Green and Grice mentioned the procedure and stated that it can be performed with successful results. Caldwell has informed the authors that H. A. Durham transplanted the posterior tibial tendon through the interosseous space in February 1936, and since then the method has been employed in a number of patients. Although there are no exact follow-up data, in general the results were satisfactory. Stubbins has prepared an article on this subject which has not yet been published. Turco has performed the operation in a number of patients. In discussing the treatment of Charcot-Marie-Tooth disease, Jacobs and Carr reported the transplantation of the posterior tibial tendon through the interosseous membrane in three patients (five feet), all with satisfactory results. These authors, however, did not describe the exact operative technique.

Since September 1951, at the New York Orthopaedic Hospital, transplantation of the posterior tibial muscle and tendon through the interosseous space to the dorsum of the foot

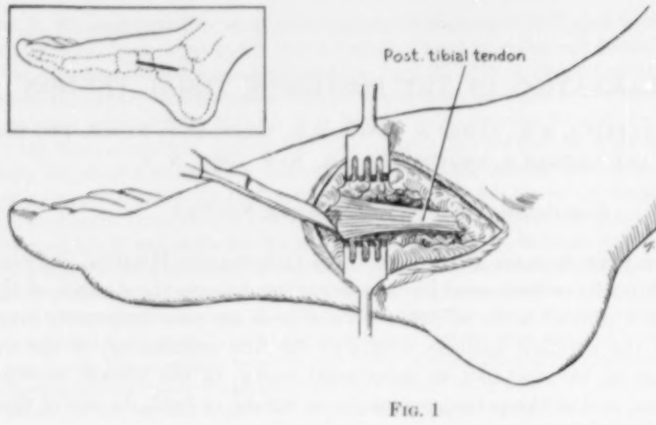

FIG. 1

Fig. 1: The first incision is made along the course of the posterior tibial tendon. The tendon is released distally to its primary insertion into the tuberosity of the navicular to gain as much length as possible.

Fig. 2: The second incision is made parallel to and lateral to the lower third of the crest of the tibia. Exposure of the interosseous membrane is accomplished by retracting the anterior tibial muscle from the lateral surface of the tibia.

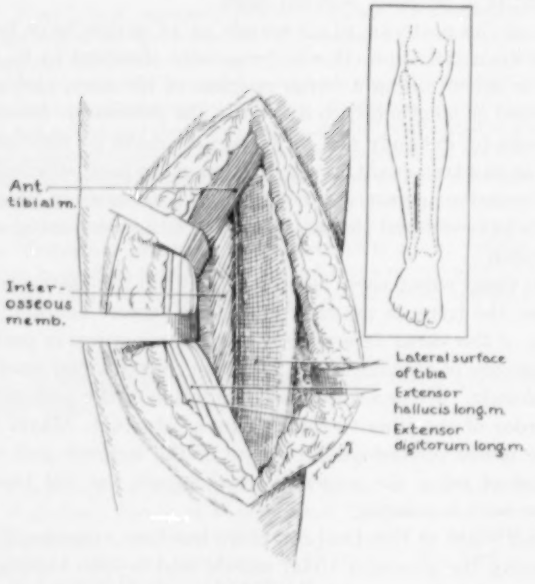

FIG. 2

has been performed twenty-nine times. Twenty-six patients were operated upon; three of them had similar procedures performed on both feet. The purpose of this paper is to describe the operative technique as followed at this Hospital and to report the functional results which have been obtained in those patients who have been followed long enough for evaluation.

PREOPERATIVE MANAGEMENT

Posterior tibial transplantation cannot be expected to produce positive correction of a fixed deformity any more than can other tendon transfers. Therefore, any structural equinus, varus, or other deformity should be dealt with before tendon transplantation, by corrective plasters, calcaneal-tendon lengthening, subtalar arthrodesis, or other procedures as the circumstances indicate, so that the foot can be placed in neutral position with at least 90 degrees of dorsiflexion.

Postoperative rehabilitation is simplified when the patient has already learned to contract the posterior tibial muscle independently and voluntarily. When possible, he should be educated to do so preoperatively.

OPERATIVE TECHNIQUE

The procedure is carried out in a bloodless field through three incisions. The first incision (Fig. 1) is on the medial border of the foot along the course of the posterior tibial tendon, from just below the medial malleolus to the medial cuneiform. The tendon is freed from its sheath and is incised distal to its primary insertion into the tuberosity of the navicular. It is important to obtain as much length of tendon as possible.

The second incision (Fig. 2) is made parallel and lateral to the lower third of the crest of the tibia. If the peronaeus longus muscle is to be transplanted at the same time, this incision is made more lateral, so that only one incision in the leg is necessary. The deep fascia is opened lateral to the crest of the tibia and the anterior tibial muscle is retracted laterally, exposing the interosseous membrane. This is easily accomplished without disturbing the periosteum of the tibia. The anterior tibial nerve and vessels lie deep and lateral to the anterior tibial muscle and are therefore protected by this muscle as it is retracted. The vessels and nerve become visible lateral to the anterior tibial tendon at the ankle, but it is not necessary to disturb them. The interosseous membrane is incised through sufficient length to allow the belly of the posterior tibial muscle to fill the interosseous space (Fig. 3). This is an important step and actually converts the posterior tibial muscle from a posterior to an anterior position. After the large opening in the membrane has been made, pressure from behind causes the muscle to bulge into the space, and the tendinous portion to become visible distally. A blunt instrument is then passed about the muscle and its tendon is pulled out. Gentle traction on the distal end of the tendon brings more of the muscle belly into the anterior compartment of the leg. Injury to the posterior tibial vessels and nerve

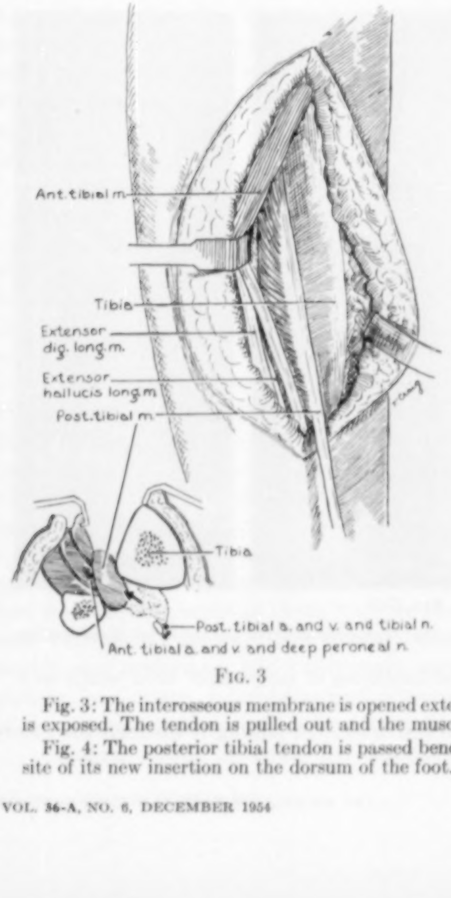
Ant. tibial m.
Tibia
Extensor dig. long. m.
Extensor hallucis long. m.
Post. tibial m.
Tibia
Post. tibial a. and v. and tibial n.
Ant. tibial a. and v. and deep peroneal n.

Fig. 3

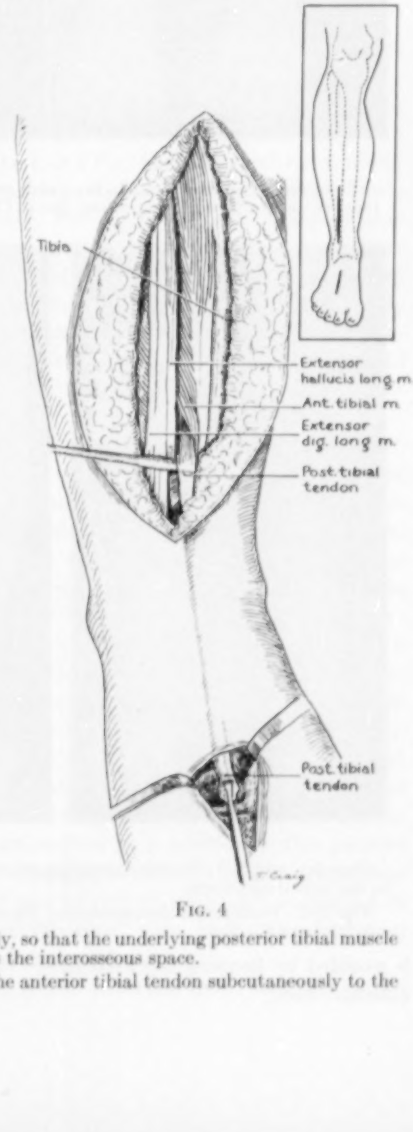
Tibia
Extensor hallucis long. m.
Ant. tibial m.
Extensor dig. long. m.
Post. tibial tendon
Post. tibial tendon

Fig. 4

Fig. 3: The interosseous membrane is opened extensively, so that the underlying posterior tibial muscle is exposed. The tendon is pulled out and the muscle fills the interosseous space.

Fig. 4: The posterior tibial tendon is passed beneath the anterior tibial tendon subcutaneously to the site of its new insertion on the dorsum of the foot.

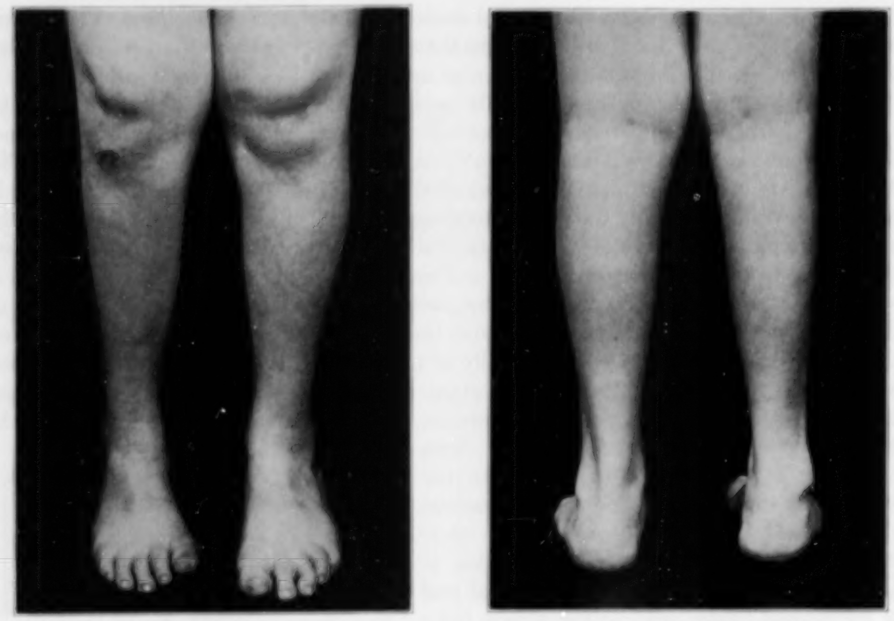

FIG. 5-A

FIG. 5-B

Preoperative photographs. L. B., a girl, seven and a half years old, had weakness of the peroneal muscles and varus of the right foot due to Charcot-Marie-Tooth disease.

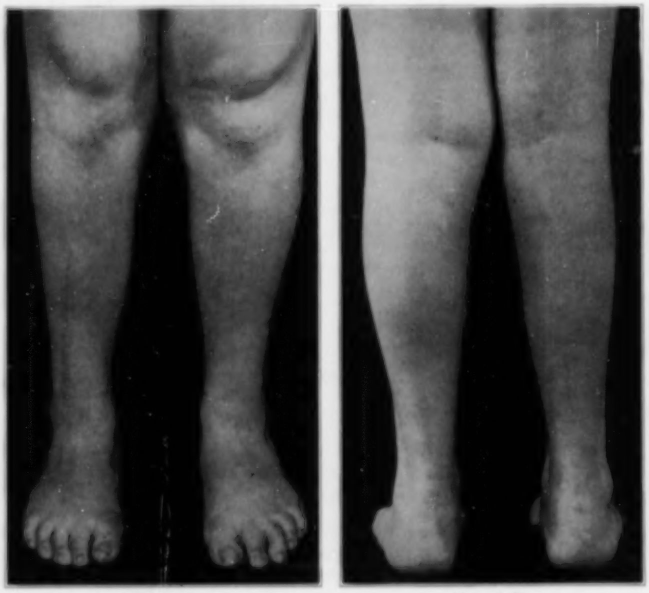

FIG. 5-C

FIG. 5-D

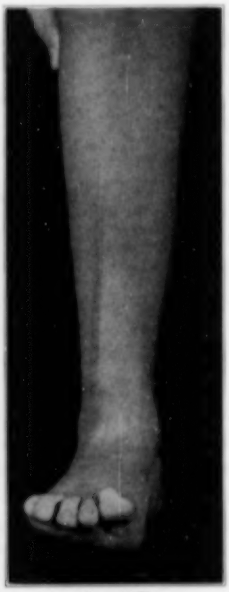

FIG. 5-E

Figs. 5-C and 5-D: Photographs taken six months after transplantation of the posterior tibial tendon to the lateral cuneiform.

Fig. 5-E: Photograph demonstrating the effective functioning of the posterior tibial tendon as a dorsiflexor of the foot.

is avoided by keeping the instrument close to the muscle in pulling it through the interosseous space.

TABLE I

SUMMARY OF RESULTS

		Results				
Diagnosis	No. of Patients	Excellent (*No. of Patients*)	Good (*No. of Patients*)	Fair (*No. of Patients*)	Poor (*No. of Patients*)	Not Known (*No. of Patients*)
Poliomyelitis	11*	6	3			2
Spastic paralysis	7	2	3	1		1
Spina bifida	3	2	1			
Relapsing club-foot	2	1				1
Peroneal paralysis (traumatic)	1	1				
Atypical muscular dystrophy	2**	2				
Friedreich's ataxia	2**	2				
Charcot-Marie-Tooth disease	1	1				
Total	29	17	7	1		4

* One patient had the procedure performed bilaterally.

** Both patients had the procedure performed bilaterally.

The third incision is made on the dorsum of the foot over the desired site of the new insertion. The posterior tibial muscle is passed beneath the anterior tibial tendon and through a subcutaneous tunnel to the dorsum of the foot (Fig. 4). It is usually not necessary to pass the muscle deep to the extensor digitorum communis and the extensor hallucis longus, although it can be done if this seems desirable. The length of the tendon available may alter the plan of location and the method of insertion. In one patient it was necessary to insert the tendon into the middle cuneiform instead of the cuboid as originally planned and, in another, into a strip of peronaeus brevis tendon, because of insufficient length. The pull out-wire technique has been most helpful in overcoming the difficulty of anchoring the tendon in several patients. In general, the location of the new insertion should depend upon the degree of imbalance and the power of the remaining musculature.

SELECTION OF PATIENTS FOR OPERATION

The most favorable results from this procedure may be expected in the varus foot with an overactive posterior tibial muscle, good calf muscles, and a deficit in power of the muscles of dorsiflexion. In this type of foot, transplantation of the posterior tibial tendon through the interosseous space to the dorsum of the foot simultaneously releases the major cause of the varus deformity and supplies a strong muscle for dorsiflexion of the foot. The first few patients operated upon in this series had foot deformities of this type. The results in these cases revealed the effectiveness of the posterior tibial tendon as a dorsiflexor and led to its use in a wide variety of conditions with muscle imbalance about the foot. In six cases, either the anterior tibial tendon or the peronaeus longus tendon was transferred to the dorsum of the foot at the time of the posterior tibial transplantation. In the remainder of the cases (twenty-three of the twenty-nine operations), the posterior tibial tendon alone was transplanted. In twelve patients, a triple arthrodesis had been performed prior to the tendon surgery. Most of the patients were too young for foot stabilization; some of them may require an arthrodesis at a later date. One patient with Friedreich's ataxia, upon whom a bilateral transplantation of the posterior tibial tendon was performed, had preliminary operative procedures on each foot consisting in plantar fasciotomy, interphalangeal arthrodesis of the great toes, and transplantation of the extensor hallucis longus tendon to the first metatarsal.

Cerebral spastic paralysis and anterior poliomyelitis were the most common condi-

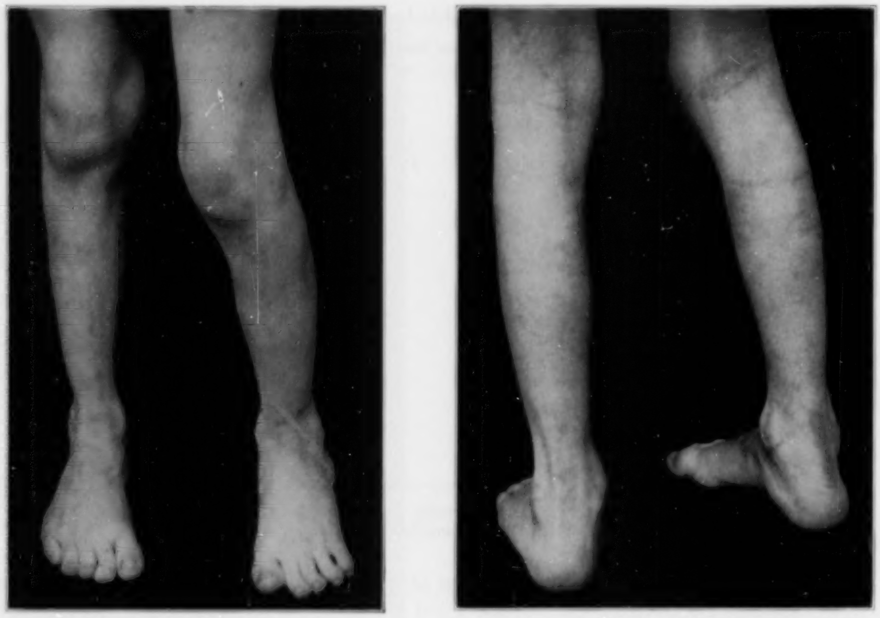

FIG. 6-A FIG. 6-B

Preoperative photographs. L. C., a boy, nine years old, had equinovarus due to spastic paralysis. Both lower extremities were involved, the right more markedly than the left.

tions for which the procedure was performed. The others were congenital club-foot, spina bifida, an atypical form of muscular dystrophy, Charcot-Marie-Tooth disease, peroneal paralysis secondary to trauma, and Friedreich's ataxia.

POSTOPERATIVE MANAGEMENT

Each patient had immobilization of the extremity operated upon in a plaster cast which maintained maximum dorsiflexion of the ankle. Except in some of the patients with spastic paralysis, it was not considered necessary to apply the cast above the knee. The initial cast was removed between ten days and two weeks after operation; skin sutures were removed and a walking boot was applied. If the pull-out-wire technique had been employed in inserting the tendon into bone, care was taken to provide protection for the button area by proper padding. Patients were discharged from the Hospital at this time. Weight-bearing in the plaster boot was permitted at two weeks. Each patient returned to the Out-Patient Clinic six weeks after surgery for removal of the cast; the pull-out wire was withdrawn at that time in those cases in which it had been used. Most patients wore short leg, drop-foot braces for three months after the cast had been removed. It is now felt that a brace is necessary only when there is a strong tendency for the foot to go into equinus, thereby exerting tension on the posterior tibial tendon. Muscle re-education and exercises are an important part of the postoperative program during this period. The new function of the posterior tibial muscle was evident immediately after removal of the plaster in those patients with spastic paralysis. The remainder of the patients had acquired the function within three months after operation; improvement in strength and control of the transplant was noted during the next three months.

ANALYSIS OF RESULTS

A tabulation of the results of transplantation of the posterior tibial tendon in twenty-nine cases is shown in Table I. In four patients a final evaluation was not possible; in two cases sufficient time had not elapsed since operation; and two could not report to the Clinic for examination. Of the remaining twenty-five, the results were excellent in seventeen; good in seven; and fair in one. A result was considered to be *excellent* if there was satisfactory improvement in the position of the foot with good power of the transplanted muscle, if the functional deformity was corrected, and the gait was significantly

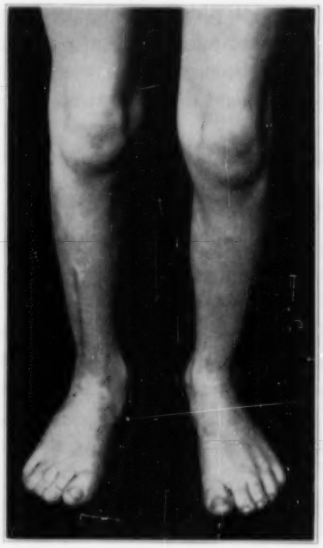

FIG. 6-C

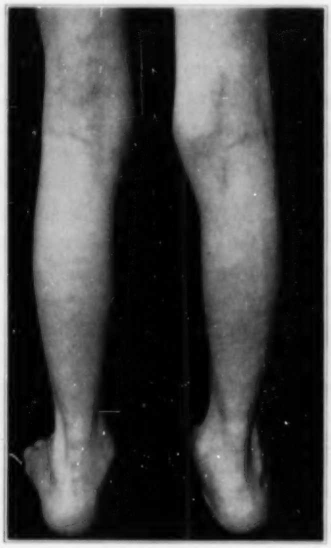

FIG. 6-D

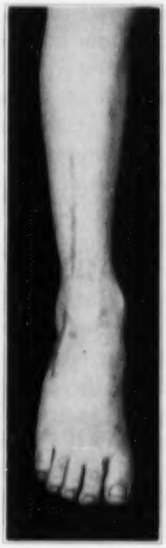

FIG. 6-E

Figs. 6-C and 6-D: Photographs made seven months after transplantation of the posterior tibial tendon to the cuboid on the right side.

Fig. 6-E: Demonstrating the function of the transplanted tendon.

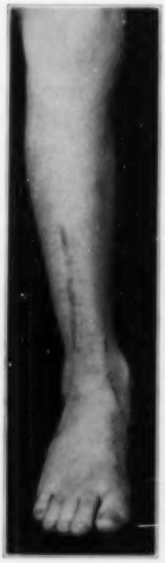

FIG. 6-F

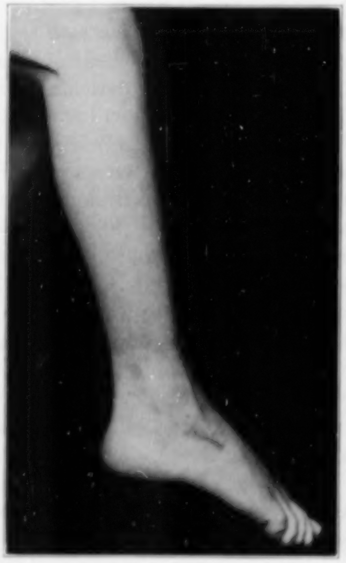

FIG. 6-G

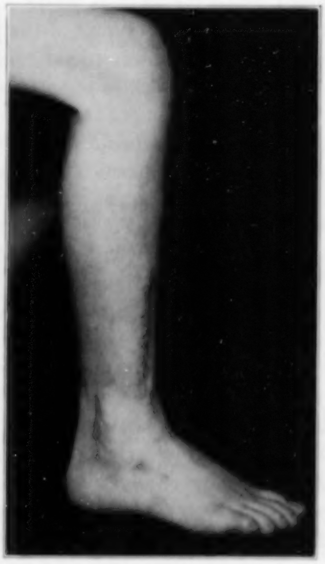

FIG. 6-H

The transplanted tendon was under voluntary control. Because of its insertion into the cuboid, a pull into valgus was obtained.

better. A result was considered to be *good* if the improvement in the gait and in the position of the foot was satisfactory but the function of the transplanted muscle was less than strong. Patients with a *fair* result showed improvement in foot position and gait, but demonstrated little power in the posterior tibial transplant. In patients with *poor* results there was no improvement over the preoperative condition.

Four cases of drop-foot (three due to poliomyelitis and one following trauma to the peroneal nerve) were corrected by transferring both the posterior tibial and the peronaeus longus tendons to the dorsum of the foot. In each instance the examiner was satisfied that both muscles were functioning, and each of these patients demonstrated strong, active dorsiflexion of the ankle. Three of these patients had stabilization operations (triple arthrodesis) before the tendon transplantations.

In two patients in this series the anterior tibial tendon was transplanted to a more lateral position in addition to the transplantation of the posterior tibial tendon. The result in one of these, a patient with spastic paralysis, is not known. The other patient, who had functional equinovarus deformity due to spina bifida, obtained an excellent correction of the deformity with good function of the transplanted tendons.

Of twenty-three transplantations of the posterior tibial tendon alone, a final evaluation was obtained in twenty operations performed on seventeen patients. Three patients had similar operations on both feet. With the exception of six cases of spastic paralysis, which will be discussed separately, the posterior tibial muscle was shown to function effectively as a dorsiflexor of the ankle in every case. There was no indication that the excursion of the tendon was restricted by transplantation through the interosseous space.

Of the six patients who had the operation performed for deformities due to spastic paralysis, function of the transplanted tendon could be demonstrated, but only two of the patients obtained voluntary control of the muscle. All of the patients, however, were significantly benefited by the operation. The varus deformity was corrected and there was considerable improvement in the functional equinus. In all of the patients with spastic paralysis it was observed that the posterior tibial muscle contracted simultaneously with the calf muscles and partly counteracted the strong pull of the calf muscles which is present when the patient walks. In one patient, in whom a gastrocnemius neurectomy had been performed, the pull of the posterior tibial muscle seemed to exceed the power of the calf muscles. This may lead eventually to the development of a calcaneus gait.

When equinovarus is the initial deformity in these patients with spastic paralysis, there may be a tendency to transplant the posterior tibial tendon too far laterally. Removing the tendon from its normal insertion relieves, in large measure, the varus element. By transplanting it lateral to the mid-line of the foot, a muscle pull favoring the valgus position is obtained. In one patient, in whom the posterior tibial tendon had been inserted into the cuboid, an undesirable degree of valgus resulted (Figs. 6-E to 6-H). This experience suggests that it is unwise to transplant the tendon as far laterally as the cuboid bone in patients with spastic paralysis. Insertion into the second or third cuneiform has given the best results in this group of cases.

Only two cases of club-foot with recurrent deformity are included in this series; the result in one of these is not known. The case available for follow-up study revealed a well functioning transplanted muscle and no further recurrence of the deformity. Transplanting the posterior tibial tendon to the lateral side of the foot (cuboid bone) should be a logical and worth-while procedure for congenital equinovarus which has been corrected and has a strong tendency to recur. One of the authors has used this procedure in three cases of relapsing club-foot with excellent results. The operations were performed at another hospital and are not included in this study.

SUMMARY

The role of the posterior tibial muscle in producing foot deformities has been stressed in the literature. The importance of releasing the posterior tibial tendon in correcting an

equinovarus deformity has been well recognized. A review of the literature, however, reveals that transplantation of the posterior tibial tendon through the interosseous space is not a well known operative procedure.

Transplantation of the posterior tibial muscle and tendon through the interosseous space is a valuable operative procedure and can be relied upon to restore active dorsiflexion of the foot. The operation is applicable to a wide variety of conditions in which the posterior tibial muscle has good power and there is a need for an additional dorsiflexor of the foot.

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DISCUSSION

Arthrodesis of the Hip in Wide Abduction

(*Continued from page 1140*)

In another case, this type of osteotomy was used to salvage a cup arthroplasty which had failed completely. The patient required motion at the hip because most of her work was done in the sitting position, but she was offered an arthrodesis as a solution to her problem. She realized that a stiff hip would handicap her greatly and welcomed the preservation of some flexion. The remainder of the neck was removed and an osteotomy was performed, the apex of the angulation being placed medially and anteriorly. This procedure gave her apparent lengthening, stability, and flexion of 90 degrees, so that she could sit without difficulty. She gave up crutches and walked with a cane, and has had freedom from pain.

The operation works equally well after failure of an endoprosthesis. The resection of the head and neck has been performed already. After the removal of the endoprosthesis, the angulation osteotomy is relatively easy.

Dr. J. Albert Key, St. Louis, Missouri: The idea of a wide abduction arthrodesis was the authors' and I had nothing to do with it. I did use it as a basis for the operation for pressure arthrodesis, which I devised about the same time, and as a basis for experimental research which I have been working on off and on ever since. I still have not been able to find out whether it is pressure or the immobilization and contact of the wide bone surfaces which is the important factor. Dr. Abbott and I argued about this in the twenties and we have not settled it yet.

(*Continued on page 1232*)

THE TRANSMETATARSAL AMPUTATION IN PERIPHERAL VASCULAR DISEASE *†

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Since 1944 McKittrick and his coworkers have used the transmetatarsal amputation in the treatment of carefully selected patients with gangrene limited to toes. Although these authors have demonstrated in a significant number of cases that the procedure is generally successful, there is still much debate as to its real value. It is apparent that many surgeons dealing with peripheral vascular disease have had no experience with this operation and hesitate to try it. There are many who still feel that an amputation above or below the knee is indicated for the treatment of arteriosclerotic gangrene of toes. Others, such as Pratt and Samuels, feel that the transmetatarsal amputation has little to offer, since it can be successful only in those patients who can be adequately managed by limiting therapy to the involved toes.

At the Dearborn Veterans Hospital, since 1947 all amputations have been performed on the Orthopaedic Service. Those patients with complications of peripheral vascular disease are seen by both the Surgical Peripheral-Vascular Service and the Orthopaedic Service, and the combined treatment program is outlined. We have been using the transmetatarsal amputation since 1950 in the belief that, as the medical and surgical treatment of peripheral vascular disease improves, patients live longer and all amputations become more successful; moreover, we believe that long-term function is a primary consideration. It is our feeling now that, in properly selected patients, the transmetatarsal amputation results in an excellent functioning extremity, with relief of symptoms, and that it often prevents a more disabling amputation at a higher level.

In peripheral vascular disease, gangrene results either from sudden occlusion of a major vessel, or from a mild precipitating factor in gradually progressive peripheral insufficiency. The common precipitating factors are exposure to heat, cold, or trauma, and infection following trimming of corns or nails, or epidermophytosis. We are concerned with this second group of patients. In that group it is recognized that the patient has a generalized disease and that, once gangrene develops in one toe, he is likely to have repeated episodes, with involvement of both feet, and with frequent periods of hospitalization. Gangrene and infection beginning in the toes is frequently progressive, spreading to the dorsum of the foot or along the plantar aspect of the foot and finally requiring a major amputation.

For these reasons it appears that, in properly selected patients with gangrene limited to toes, removal of all the toes is indicated both as treatment for the presenting disease and as a prophylactic measure.

We have now performed twenty-three transmetatarsal amputations for gangrene with results which parallel those of McKittrick and his associates. On the basis of that experience we would like to discuss the proper selection of patients, the preoperative preparation, the operative technique, and the postoperative care, with a few additional remarks on the rationale of treatment. It is hoped that there will be a more widespread use of this operation.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1954.

† Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

According to McKittrick and his coworkers, the operation is indicated for gangrene of all, or a part, of one or more toes, providing the gangrene and infection are stabilized and do not involve the dorsal or plantar surfaces of the foot. They also include those patients who have stabilized open infections in the distal portion of the foot, if the entire lesion can be excised and primary closure can be obtained. They emphasize that it is difficult to determine the possibility of success in a foot with deficient circulation on any basis other than clinical judgment. In general, the poorer the circulatory and nutritional status of the foot, the less chance there is of success. However, the absence of palpable pulsation below the iliac or femoral artery is no contra-indication to this operation. The special diagnostic measures used in peripheral vascular disease have been of no material benefit. If the skin on the dorsum of the foot is warm and has good nutrition, success can be expected. Many patients fall into a borderline category and must be advised that the possibilities of healing are questionable. However, there are many patients with healed transmetatarsal stumps who preoperatively had no pulsation below the femoral artery and who had cool, shiny, thin skin on the dorsum of the foot. Success has not been seen in cases in which there was discoloration on the dorsum, except for redness from inflammatory changes.

The preoperative period of preparation is considered to be the most important factor in determining success. During that period of two to three weeks, the patient is restricted to bed rest with the extremity flat in bed, and with the head of the bed elevated a few inches. It is hoped that this rest will decrease the circulatory requirement, prevent additional trauma, allow the control of infection, and prevent the extension of gangrene. Transmetatarsal amputation is indicated for those patients whose gangrene is stabilized and not progressive.

During the period of preparation, the control of infection is an important problem. The presence of infection should be assumed in all patients, including those who have been classified as having "dry gangrene" or ischaemic necrosis. It is always possible, in these mummified toes, to demonstrate that at the line of demarcation there is a break in the skin, and in most cases there is a small amount of pus. In these patients, unless suitable precautions are taken, infection is introduced. Therefore, all patients are given antibiotics, and loose sterile dressings are worn at all times. The sterile dressings are removed once or twice daily for a fifteen-minute foot bath in tepid water to which some white soap has been added. The foot baths are used to promote drainage and to allow a gentle débridement. In the foot bath, necrotic tissue which is spontaneously separating can be removed with forceps and scissors, but viable tissue should never be touched.

Infection as a major problem is usually found in the group of diabetics with arteriosclerosis. There may be gross spreading infection, particularly along the tendon sheaths in the plantar aspect of the foot, requiring amputation of a toe or a wide incision and drainage, including the removal of the toe and its metatarsal. Only when infection has been completely controlled and it is obvious that there is no progression of gangrene, can the transmetatarsal amputation be considered.

Several important points in the operative technique must be considered. The amputation level is just proximal to the metatarsal heads, so that at the conclusion of the amputation, for all practical purposes, there is only bone between dorsal and plantar layers of skin and subcutaneous tissue. A more proximal level would pass through the deep structures of the foot, including relatively ischaemic muscle. The dorsal incision begins mid-way between the dorsal and plantar surfaces on either side, and with one sharp incision down to bone it is continued in a straight line across the dorsum to the mid-point on the opposite side. This is at the level of bone amputation, no dorsal flap being formed. The plantar incision begins at either end of the dorsal incision and parallels the proximal flexion crease of the toes, but runs one centimeter proximally to the flexion crease. This incision likewise must be sharp and directly down to bone. The long plantar flap thus obtained is dissected back to the level of bone amputation. The metatarsal heads, beginning with the first, are then removed with a saw. The saw blade is allowed to rest against the previously cut metatarsal, which serves as a guide, so that an even stump is formed. The plantar tendons and sesamoids are then removed at the bone level. The closure is made preferably in one layer with non-absorbable suture. As atraumatic a technique as possible is mandatory. At no time should the skin margins be touched with forceps. Tissues should be handled lightly with the fingers and a moist gauze sponge. Also, the closure should be meticulous, leaving no dog-ears, as these will slough out. A large bulky dressing is applied to the whole foot and ankle, with gentle pressure. Since these feet will not tolerate much pressure, the skin over the malleoli and the base of the fifth metatarsal should be carefully padded, and adhesive tape should never be placed directly on the skin.

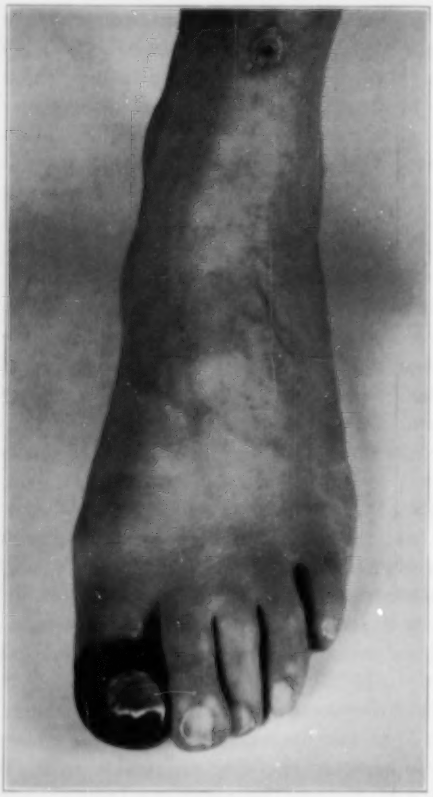

Fig. 1-A

A male, sixty-four years old, with arteriosclerosis. Gangrene of the first toe had developed subsequent to the trimming of a callus.

After operation the patients return to strict bed rest, with the head of the bed slightly elevated. At least half of the sutures should remain in place for two weeks. Buerger's exercises are begun ten days to two weeks after operation, in preparation for ambulation at three weeks; by that time, healing is usually complete if it took place by primary intention. The patient at first walks with loose slippers until all swelling has gone and then wears his usual shoes. The toe is stuffed with wool or cotton and a thin piece of spring steel is placed between the layers of the sole. Some patients have preferred to remove the spring steel. The final gait is excellent at a moderate walk, but a limp appears with increasing rates of movement.

Deformities from unbalanced musculature do not develop in the stumps, and they will stand up well under use. While we have adequate follow-up studies on the series to be reported here, the figures of McKittrick and his associates [2] are more significant. They reported on a group of diabetic patients followed for as long as fifty-seven months. Of 146 patients who left the hospital with healed stumps, ulceration recurred in only twenty-four, or 16 per cent., and only six of these had amputation at a higher level. They reported that, of 202 patients followed, 135, or 67 per cent., had satisfactory results; thirty-two, or 16 per cent., had unsatisfactory results (they were ambulatory, but with incomplete healing or recurrence of ulceration); and thirty-five, or 17 per cent., had failures (with progressive difficulty and amputation at a higher level).

Using the technique described, we have performed twenty-three amputations on twenty-one patients with peripheral vascular disease. Of these, three were for thromboangiitis obliterans, five for arteriosclerosis, and fifteen were for diabetes with arteriosclerosis. With one exception, all had gangrene limited to one or more toes, associated with mild to moderate local cellulitis. The exception was a diabetic patient with a persistent ulcer in a first toe, associated with severe rest pain.

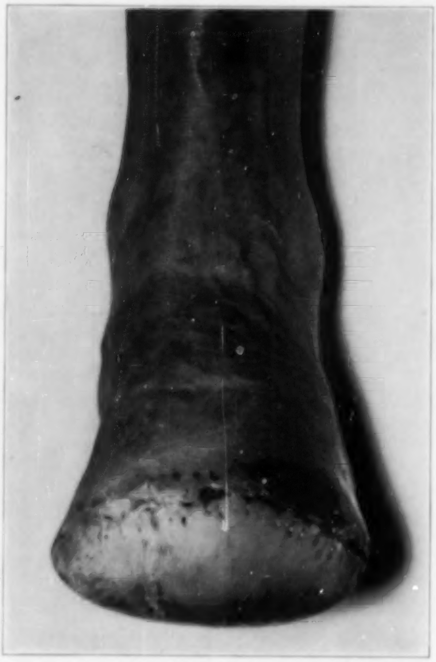

FIG. 1-B

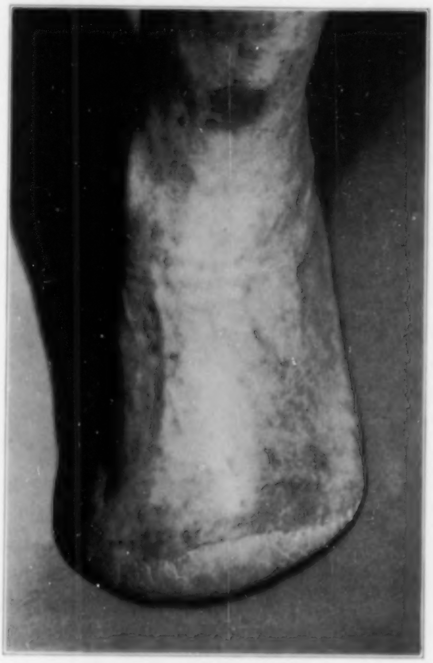

FIG. 1-C

Fig. 1-B: Two weeks after transmetatarsal amputation, without sympathectomy, there was primary healing. The discoloration on the dorsum of the foot occurs frequently and in some cases becomes a necrotic slough.

Fig. 1-C: Healing was uneventful, and the patient is asymptomatic; he is at work as a hotel clerk.

Eight patients had primary healing; nine had secondary healing; four still have small granulating areas which are expected to heal; and two had gross failures. The two failures were due to progressive gangrene beginning at the amputation site; they occurred in patients who were known to have such extensive disease that success was most unlikely. These patients finally had reamputation above the knee.

It is believed, however, that, no matter what criteria are used for selecting patients, there will still be some failures. Moreover, it is probably true that, unless there is a certain percentage of failure in any series, not enough transmetatarsal amputations are being done. The patient and his relatives should be advised that failure or delayed healing is a definite possibility and, unless both the patient and the physician are prepared to deal with these complications, the operation should never be attempted.

The two most common causes of delayed healing are marginal necrosis of the wound edges and wound infection. We include with marginal necrosis the sloughing of dog-ears and extension of gangrene to the dorsum of the foot. With wound infection we include minor stitch abscesses and gross wound infection. A discussion of these complications is of importance, because they occur frequently and because, if they are not managed properly, the percentage of failure increases sharply. In the ischaemic extremity the balance between the available blood supply and the need for nutrition is so fine that any wound complication is likely to tip the balance toward gangrene. Any incision will increase the demand for blood. The wound complications, therefore, should be treated in the same fashion in which the foot was prepared for surgery, that is, with antibiotics, sterile dressings, and daily tepid soaks, allowing for drainage, spontaneous separation of necrotic material, and healing by granulation tissue. We feel that surgical removal of eschars, secondary closures, and skin-grafting should be avoided.

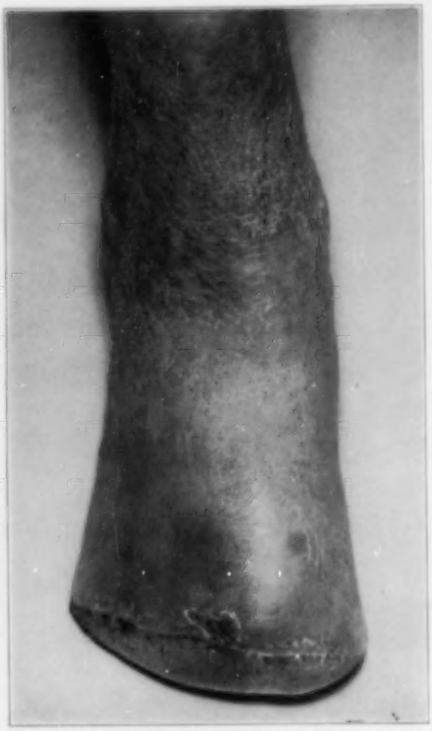

FIG. 2-A

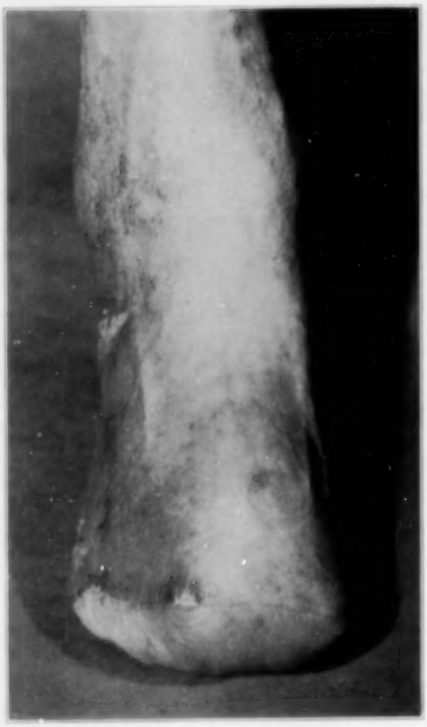

FIG. 2-B

Fig. 2-A: After lumbar sympathectomy, a transmetatarsal amputation was performed. Healing was complicated by a stitch abscess.

Fig. 2-B: Healing was complete three months after operation.

Marginal wound necrosis and moderate extension of gangrene occurred seven times; in one of these cases this was due to the slough of a dog-ear. Of these, four patients have obtained separation of the eschar and final healing, and three have small, clean, granulating areas of less than one square centimeter, which are expected to heal. The time required to achieve healing is of great importance. The four stumps which healed did so in three, three and a half, twelve, and fifteen months. In the three stumps not quite healed, the interval since operation was nine, fifteen, and sixteen months at the time of writing. However, all of these patients were ambulatory on crutches, beginning about two months after operation, when the eschar separated and granulations appeared.

Postoperative infection occurred in six patients. Two patients had small stitch abscesses. Each of these required three months before complete healing under the regimen described above. In four patients there was gross infection of the entire wound. Three of these were diabetics with infected necrotic toes who had been operated upon when it was felt that the infection was adequately controlled. At the time of operation in one it was obvious that there was some extension of infection along the flexor tendon sheath. This was probably true in the others also. The fourth patient with gross wound infection had Buerger's disease; because of his excruciating pain, he had been operated upon before the infection was completely controlled. In these four patients all sutures were removed; the flap was completely freed; and the wound was thoroughly irrigated. They were again treated with daily soaks and sterile dressings, with suitable antibiotics. Without additional surgery each of these wounds healed uneventfully in four, four, five, and seven months,

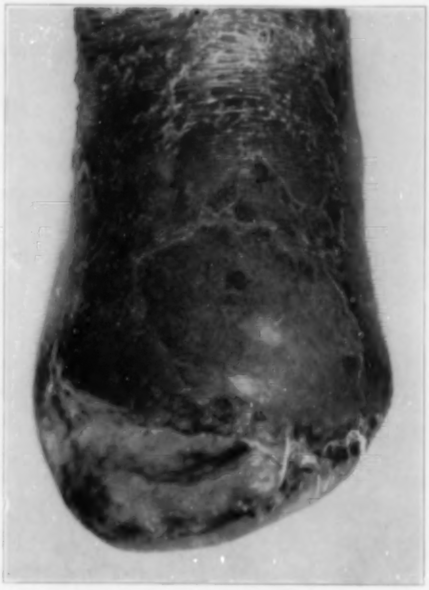

FIG. 3-A

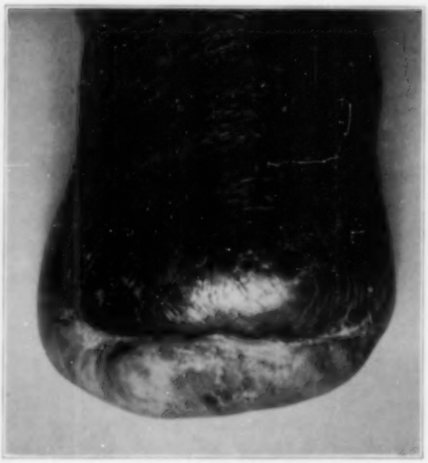

FIG. 3-B

Fig. 3-A: After transmetatarsal amputation, there was a gross wound abscess.

Fig. 3-B: With foot baths, rest, and sterile dressings, and with no additional surgery, healing was complete in five months.

respectively. The flap was pulled up over the bone end by granulation tissue, and good functional stumps resulted. When infection is the primary problem, it can be handled if drainage is adequate. This experience is similar to that reported by Furste and Herrmann.

In the consideration of specific factors which contribute to success or failure, an attempt was made to correlate palpable pulsation in the extremity and the rate of healing. Only three patients had palpable pulsations in the foot. Of these, one had healing by primary intention, in one there was marginal necrosis with eventual healing in three and a half months, and in one there was a small stitch abscess which was finally controlled in three months. Of five patients whose most peripheral palpable pulse was the popliteal, three had healing by primary intention, one had a stitch abscess which was controlled in three months, and one had a gross wound abscess with healing in four months. Of fifteen patients whose most peripheral palpable pulse was the iliac or femoral, four had healing by primary intention; in six healing was complete but delayed; in three healing was incomplete at the time of writing but is expected; and two had gross failures. Thus the failures and those with unduly prolonged healing are in the group with no pulsation below the femoral artery. While it is obviously true that the poorer the circulation, the less chance there is of healing, success or failure cannot be determined on the basis of palpable pulsation. McKittrick and his associates emphasized that there are frequent surprises in both directions. Success or failure is probably determined by the extent of collateral circulation which has developed and there is no accepted method of determining that collateral circulation except the purely clinical. None of the objective methods has been so successful as inspection of the leg for the color and nutrition of the skin and subcutaneous tissues, palpation for warmth, and clinical experience.

Although little work has been done on the problem, there is some experimental evidence and much clinical evidence that the transmetatarsal amputation takes great advantage of the collateral circulation as it develops in the leg. Injected specimens, such as were illustrated by McKittrick and Root, as well as some of our own, suggest that there are areas where collateral circulation develops with ease and others where it is virtually impossible. It is felt that there are few, if any, collateral vessels in the toes, the dorsum

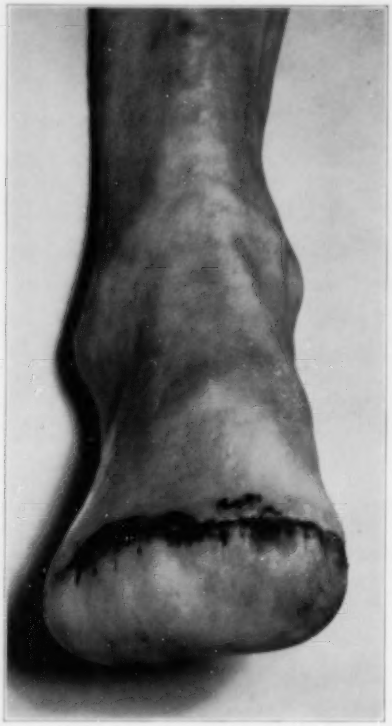

FIG. 4-A

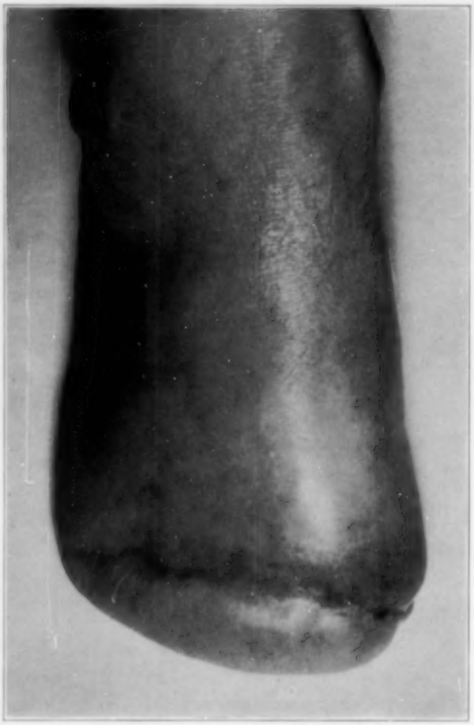

FIG. 4-B

Fig. 4-A: A diabetic, sixty-two years old, treated for gangrene of the first toe. There was no pulse below the femoral, and the skin on the dorsum of the foot was cool, shiny, and atrophic. Two weeks after transmetatarsal amputation there was marginal necrosis and discoloration of the medial portion of the plantar flap.

Fig. 4-B: With conservative care the patient became ambulant early, but complete healing required fifteen months of treatment.

of the foot, and along the anterior aspect of the leg. On the other hand, there may be many fine collateral vessels in the plantar subcutaneous tissue. When postoperative gangrene is seen after amputations for peripheral vascular disease, it is almost always confined to the dorsum of the foot in the transmetatarsal amputations and amputations of single toes, and to the anterolateral skin flap in the below-the-knee amputation. A great part of the success of the transmetatarsal amputation is due to the use of a long plantar flap of skin and subcutaneous tissue without a dorsal flap. Likewise, the amputation is performed far enough distally so that the deep structures of the foot are not involved.

If the development of collateral circulation is of importance, the role of preoperative lumbar sympathectomy must be evaluated. The patients in this series were seen by the Surgical Peripheral Vascular Service, who performed lumbar sympathectomy upon fourteen of the twenty-one patients. The results, in that group, parallel those in the group as a whole, with variation from primary healing to complete failure and early high amputation. One of these patients, who had palpable pulsations in the foot, still had marginal necrosis following his amputation, final healing being delayed three and a half months. On the other hand, among those for whom sympathectomy was felt to be of no value was a man, seventy-five years old, with pipe-stem vessels visible in roentgenograms of the feet; his most peripheral palpable pulse was the femoral artery and his wound healed by primary intention, except for a small dog-ear which sloughed and healed.

It is the authors' belief that with the material available in this study we cannot evaluate the role played by lumbar sympathectomy in the final results. The series is too small, and the records of the response to sympathectomy are too inaccurate. According to our clinical observations in this type of patient, it did not influence the final outcome. Warren and his associates reported similar observations. There was, however, no extension of gangrene which could be attributed to lumbar sympathectomy. Since there have been no complications of sympathectomy, and there has been no accurate method of preoperatively evaluating the postoperative response, the operation has been recommended whenever it was felt that any degree of response might follow. It is possible that many of the good results are in part due to increased peripheral blood supply following lumbar sympathectomy.

Sympathectomy in the past has been recommended as a means of controlling rest pain. It has been well established that in many cases of intermittent claudication the response is dramatic. In this series we were concerned, however, with persistent pain in the toes with or without an open, infected lesion. In five of these patients such pain was a major complaint and in no case did sympathectomy relieve the pain. On the other hand, all five were completely relieved following transmetatarsal amputation when the wound was completely healed. One of these patients had healing by primary intention and was relieved immediately. One had a non-infected marginal necrosis after operation. He was completely relieved until the eschar separated, exposing granulating tissue. His pain returned, and disappeared finally when the wound was completely healed. Two of the patients with Buerger's disease had exquisite pain preoperatively, as well as postoperatively while infection was present. They likewise were relieved when healing was complete. It is believed that pain in these patients is due in large part to involvement of peripheral nerves by fibrosis and acute inflammation.

In many patients pain is so severe and so persistent that large doses of narcotics are necessary and the patients become severe nursing problems. Many limbs under such circumstances have been needlessly sacrificed at the patient's insistence. Pain in the toes at the site of an open lesion is not an indication for a major amputation. These patients do not become narcotic addicts. In each of the cases mentioned the patient stopped asking for relief when his lesion was healed.

From the combined experience of those who have used the transmetatarsal amputation in peripheral vascular disease it is apparent that it is possible in a high percentage of patients to obtain well healed stumps. In any discussion of the use of this type of amputation three specific criticisms can be made. The authors feel that these criticisms should be mentioned and discussed briefly.

First, it is believed by some that using a conservative amputation merely delays the inevitable amputation at a higher level. In the present series there were only three late complications. In one patient, fourteen months after complete healing, gangrene of the entire leg developed and a reamputation was performed; in one patient, one year after complete healing, a small superficial infection developed which was easily controlled; and one patient died of coronary-artery disease three months after complete healing. In the follow-up study of McKittrick and his coworkers [2] only six of 146 patients had reamputation at a higher level.

The second criticism is that many of the patients suitable for transmetatarsal amputation need only removal of the involved toes. Yet, if treatment is limited to the involved toes, several months are frequently required for complete healing. After this treatment, gangrene may at any time develop in the remaining toes, the most vulnerable part of the extremity. Of the twenty-one patients in this series, nine had had one or more previous hospital admissions for the treatment of gangrenous toes. In such episodes it may not be possible to prevent the spread of gangrene and infection to the foot, or, therefore, to prevent a major amputation.

The third criticism is that for some patients too long a time is required for delayed healing, resulting in great economic loss and delay in rehabilitation. In this group of twenty-three amputations, there were thirteen instances of delayed healing, or 56 per cent. of the total. In most cases the patients were ambulant and might have been out-patients after two months. In this group only five stumps have required longer than seven months to heal satisfactorily, and in each of these there was some reason for feeling that prolonged treatment was justified. One patient accounted for two of the five stumps. He was an elderly diabetic with no peripheral pulse below the femoral on either side. At different times gangrene of the first toe in each foot developed. On each side, when demarcation was complete, a transmetatarsal amputation was performed. At the time of each amputation he had rest pain, marked atrophy of the leg, and cool, thin, shiny skin on the dorsum of each foot. One stump healed in fifteen months and the other was almost healed at fifteen months. In many clinics both extremities would have been treated by amputation above the knee.

It is unfortunate that this serious disease occurs primarily in elderly people. There is always bilateral involvement and, in the event of bilateral high amputations, these patients do not successfully wear prostheses and a wheel-chair existence results.

It is the authors' impression that the more widespread use of the transmetatarsal amputation will prolong the productive lives of many patients.

NOTE: The authors wish to thank Mr. Earl Bartlett, medical photographer at Dearborn Veterans Hospital, who took the photographs used to illustrate this paper.

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DISCUSSION

DR. DONALD B. SLOCUM, EUGENE, OREGON: Prior to World War II it was standard practice to amputate the gangrenous extremity of the patient with peripheral vascular disease, either through the necrotic portion of a gangrenous toe or above the supracondylar level. During the past decade amputations below the knee and through the fore part of the foot have been noted with increasing frequency. Such presentations as this one of Dr. Pedersen and Dr. Day's have led us to ask: (1) Why this trend toward conservatism? (2) Is the transmetatarsal amputation a good procedure? (3) What are the indications for this amputation?

The trend toward conservatism is based on the marked reduction in morbidity and mortality after amputation procedures. Three factors are primarily responsible for this. First, improvement in anaesthetic methods and geriatric care. Second, the better control of infection because of the intelligent use of rest and antibiotics, and the development of meticulous dressing techniques both preoperatively and postoperatively. Third, the fear that reamputation will be necessary because of infection and spreading gangrene has been diminished, since the latter occurs less frequently, and is more readily controlled when it does occur.

As to the second question—Is metatarsal amputation a good procedure?—there is little doubt that a well healed, painless amputation stump at the level of the metatarsal necks is satisfactory for patients with peripheral vascular disease. Rapid gait, squatting, and tiptoeing are virtually lost, but moderate to slow gait is good. In the age group concerned, this last function is all that is usually required. No prosthesis is necessary and only stuffing of the toe and occasionally a spring steel in the sole of the shoe are required. For patients with peripheral vascular disease, the fact that transmetatarsal amputation provides relatively normal gait and requires no prosthesis is of no mean importance and is a definite advantage over amputation at a higher level, since the increased strain imposed on the opposite extremity by the prosthetic gait may precipitate gangrene in that member.

The question of indications for transmetatarsal amputation may be broken down into two further questions: (1) When may transmetatarsal amputation be done? and (2) Should it be carried out in preference to amputation of the toe?

Transmetatarsal amputation is contra-indicated when gangrene is due to sudden major arterial occlusion. Under such circumstances the extremity must be amputated at a level compatible with tissue healing and the use of a prosthesis.

The operation is indicated when gangrene of the toes is due to progressive peripheral insufficiency, provided that the progress of gangrene is stabilized to a point of demarcation, infection is controlled, and the circulation of the skin on the dorsum of the foot is adequate. Since the decision for amputation is based on clinical judgment rather than upon standard testing methods, the procedure must be performed by an experienced clinician.

The answer to the question whether or not transmetatarsal amputation should be done in preference to toe amputation is more difficult. The authors say, in effect, that involvement of a single toe is the precursor of further and more extensive gangrene and that it is well to carry out amputation of the fore part of the foot as a prophylactic measure. Others feel that, if the circulation is adequate to support the minimum metabolic requirements of the tissues, as well as the reactionary inflammation which limits the extension of gangrene and infection, the circulation will be adequate to support the trauma of toe amputation. It is my feeling that in limited gangrene of a single toe, when amputation may be carried out through healthy tissues, such as the neck of the first or fifth metatarsal or the proximal phalanx of the second, third, or fourth toes, this is the procedure of choice. However, if more than one toe is involved or if a second toe amputation is required, transmetatarsal amputation should be considered on the basis of prophylaxis.

Dr. Harry D. Morris, New Orleans, Louisiana: I have had little first-hand experience with the technique described, principally because transmetatarsal amputations for peripheral vascular disease are rarely performed by those of us who do the majority of amputations in our area. Another reason, however, may well be that, as Dr. Pedersen has pointed out, because we have had little experience with the operation, we hesitate to try it. We all agree that a successfully performed transmetatarsal amputation is superior to other lower-extremity amputations for the elderly, principally because it eliminates the necessity for special prosthetic devices. In addition, because of the availability of antibiotics and the improved medical and surgical treatment of peripheral vascular disease, particularly adjunct sympathectomies, amputations at lower levels are now much more feasible than formerly. In our Clinic, we strongly believe that sympathectomies are not only helpful in relieving the symptoms of both vasospastic and degenerative organic disease of blood vessels, with or without diabetes, but also give a much better prognosis in patients with impending gangrene.

One disadvantage of the transmetatarsal technique, particularly in private patients, is the prolonged period of preoperative preparation and the relatively long postoperative period of observation necessitated by the frequent development of complications. Moreover, the surgeon must be extremely careful to perform an amputation at a level which will ensure as far as possible that amputations at a higher level will not be necessary later. These disadvantages, however, are not as great a consideration for patients in public institutions, for whom prolonged hospitalization is not an economic problem.

In some hands, the percentage of successful results after transmetatarsal amputations has not been nearly as high as that reported by Dr. Pedersen. Furste and Herrmann in 1948 reported forty-one diabetics, with satisfactory results in 37 per cent.; twenty-six patients with arteriosclerotic gangrene, with satisfactory results in 31 per cent.; and twelve patients with frostbite, with satisfactory results in 92 per cent. However, the early cases in that series were seen in 1934 before the advent of penicillin and the operations were performed without primary closure; this undoubtedly accounts for many of the failures.

I wish to re-emphasize the point made by Dr. Pedersen that atraumatic handling of tissues, particularly of skin flaps at the time of amputation, is paramount. Also, determination of the possibility of a successful result of amputation at any site in an extremity with deficient circulation depends entirely on the clinical judgment of the operator and special diagnostic measures are of little value.

I am sure that reports of this type with careful follow-up studies will result in much wider acceptance of this procedure, which has unquestionable advantages when performed according to the indications.

Dr. Pedersen (closing): One point I think is sometimes overlooked—there are two types of patients with gangrene limited to toes. One is the man who has just had a sudden occlusion of a major vessel and who, after conservative care, has gangrene limited to toes. Every time we have done a transmetatarsal amputation in that type of patient, we have had difficulty. Our two failures and many of the cases of delayed healing occurred in that type of patient. I do not claim that this type of amputation is superior to others, but I would like to point out that it is a useful procedure which has much to recommend it. Whether or not we choose to do this operation in preference to amputating a single toe is a matter of individual preference. I think there are many reasons for saying that amputation of the toe involved has distinct disadvantages. Most of the amputations of single toes depend upon some kind of incision which encroaches on the dorsum of the foot. The skin of the dorsum is particularly vulnerable and for that reason there is a high incidence of delayed healing in patients who have amputation of a single toe. My personal feeling is that there is a high

(Continued on page 1218)

TRIGGER-FINGER IN ADULTS AND CHILDREN

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Stenosing tenovaginitis is a constriction of the tendon sheath, usually associated with an incongruous tendon surface and resulting in interference with the normal smooth gliding of the tendon within its sheath. When the flexor tendon sheaths and tendons of the fingers are involved, snapping or triggering may occur as a result of the sudden blockage of the tendon prominence against the stenosed sheath and the abrupt release following the increased force required to pass the obstruction. In some instances, passive assistance from the other hand may be required to complete extension or flexion of a finger, and occasionally in the adult and usually in children, locking is present. Lipscomb[20] in a thorough study of 651 cases of chronic non-specific tenosynovitis seen at the Mayo Clinic from 1935–1948 estimated that in approximately 58 per cent. there would be involvement of the forearm, wrist, and hand, and in approximately 20 per cent. of the cases involving the wrist and hand there would also be stenosis of the digital fibrous sheath in the region of the metacarpal head, resulting in trigger-finger.

While the tendon sheath on the lateral aspect of the radial styloid process is the most frequent single site of stenosing chronic non-specific tenosynovitis, de Quervain's syndrome[17], we have observed only one case in which this syndrome was responsible for snapping of the entire thumb when abduction and flexion occurred. The thumb is practically the exclusive site of occurrence in the child and is affected more frequently than all the other fingers in the adult. The deep fascia at the metacarpophalangeal joint is thickened to form pully ligaments, and the synovial sheaths diminish friction and favor smooth gliding of the tendon within its sheath. The constriction occurs in this region when the prominent digital fibrous sheath has become thickened and stenosed.

Triggering may be confused with joint instability at the interphalangeal joints, and locking, either in flexion or extension, may be mistaken for disturbances of tendon or nerve function.

The authors have previously reported on the syndrome of "snapping-thumb", also known as "trigger-thumb" and "stenosing tenovaginitis of the flexor pollicis longus", as it occurs in children. Since that time, with the accumulation of additional cases, they have become interested in the comparison of snapping fingers in children and adults from the standpoint of incidence, clinical and pathological findings, and response to treatment. During the past eight years, thirty-one adult patients have been treated for stenosing tenovaginitis of the long thumb flexors; in these patients, thirty-four thumbs were involved. Twelve children have been treated in whom fifteen thumbs were affected. Nineteen patients had involvement of twenty-eight fingers other than the thumb.

STENOSING TENOVAGINITIS OF THE THUMB IN TWELVE CHILDREN

The twelve children mentioned ranged in age from seventeen months to eight years, the average age being four years. Seven were females (58.3 per cent.) and five were males (41.7 per cent.). The age at which symptoms were first observed varied from birth to four and one half years, the average age being 2.4 years. Symptoms had been present from one day to five years before the child came under observation, the average duration being 2.3 years. The right thumb was involved six times (40 per cent.) and the left thumb nine times (60 per cent.), and three cases were bilateral (25 per cent.). One of these bilateral cases occurred in a fraternal twin. Only one patient had a history of injury; a burn had occurred on the palm a few months previous to the onset of symptoms. Eleven thumbs were locked in flexion and could not be extended, even with force. None of these children had a previous history of snapping. The flexed distal phalanx could usually be flexed actively or passively, but extension was blocked at 20 degrees to 50 degrees from complete extension.

Each of these patients had a firm, palpable, non-tender nodule over the metacarpophalangeal-joint region. In some cases, particularly in older children, the nodule was very round and distinct. It moved with the tendon and, at operation, was found to be a tendon nodule which accounted for most of the prominence in this region. Forced motion in order to obtain extension frequently caused blanching of the skin in the region of the nodule and discomfort to the child.

In one case, there was a flexion deformity of the thumb; however, the thumb could be extended by moderate passive assistance, associated with a snap, and it subsequently assumed the flexed position. In two thumbs, snapping was present in both flexion and extension. In one of these, a tendon nodule was also palpable distal to the nodule at the base of the thumb when the thumb was in extension. This moved with the tendon and was not palpable when the thumb was flexed. A girl, five years of age (Case 2), whose thumb had first been noticed to snap at two months of age, was seen with the distal phalanx locked in extension, active motion being free from complete extension to 30 degrees of flexion when even forced motion was unsuccessful in flexing the thumb. An additional nodule was palpable distal to the digital fibrous sheath and moved with the distal phalanx. At operation, this was found to be a tendon nodule (Fig. 3-B). This impinged against the distal edge of the tendon sheath when the phalanx was flexed 30 degrees and produced blockage.

Local excision of the tendon sheath through a transverse incision at the base of the thumb was carried out on twelve thumbs in ten patients, with satisfactory results. Only the skin was sutured, and early active motion was encouraged.

STENOSING TENOVAGINITIS OF THE THUMB IN THIRTY-ONE ADULTS

Thirty-one adult patients were seen with trigger-finger, snapping-finger, or stenosing tenovaginitis of the flexor pollicis longus tendon. All of the adults were females. The age at examination ranged from twenty-nine to seventy-three years, the average age being fifty-two years. At the time the condition occurred, one patient was in the third decade, one in the fourth, ten in the fifth, twelve in the sixth, six in the seventh, and one in the eighth. Bilateral involvement was present in three cases (9.7 per cent.). Of the thirty-four thumbs affected, eighteen were right thumbs (52.9 per cent.) and sixteen were left thumbs (47.1 per cent.). The duration of symptoms varied from two weeks to two years, the average duration being 2.6 months. Snapping in flexion and extension occurred in twenty-eight thumbs. Two of these had double snapping in both flexion and extension.

Five cases were seen with the thumb in extension and loss of active flexion except for 10 to 15 degrees. In two of these, passive force produced more flexion but not complete flexion, and, in another, full flexion was possible with passive aid. In these three cases, flexion by passive force was not accompanied with a snap, and the thumb sprang back into extension when the force was released. At operation in these cases, the tendon prominence was found to be blocked by the stenosed sheath when the thumb was passively flexed and buckling occurred. In another case of extension deformity, the thumb snapped into flexion and back into extension with force. In one case, the thumb that was in extension could be passively flexed with a snap and could be actively extended. One thumb in flexion required passive aid to extend but could be actively flexed. In one case, snapping of the ring finger subsequently developed on the same side, and, in another case, multiple bilateral triggering of the lesser fingers developed.

In all cases, there was a firm palpable mass at the base of the thumb, and in no instance was there a separately palpable tendon nodule. Motions of the thumb did, however, frequently cause the mass to become slightly more prominent as the tendon enlargement passed through the stenosed sheath. The short duration of symptoms in the adult, as compared with that in the child, may account for the relatively minor involvement of the tendon in the adult, as compared with that in the child.

In twenty-six patients, twenty-nine thumbs were operated upon. In our adult patients, the tendon sheath was grossly thickened and stenosed; it was this change which accounted for most of the nodular mass. The tendon prominence was less than that found in children and varied from minimal granulations to degenerative changes resulting in some types of nodular formation. In a few instances, it was difficult to detect grossly the pathological changes in the tendon that might account for the irregularly produced snapping.

Local excision of the tendon sheath and early motion gave excellent results without complication in all but two cases. In one case with bilateral involvement, a superficial skin infection developed, but it responded to hot wet dressings and the patient made a good recovery. Another patient complained of numbness on the volar surface of the thumb for a considerable period and had some loss of flexion. Two patients who were not operated upon are free of symptoms, and another still has symptoms. A woman, forty-five years of age, had had pain in the interphalangeal joint of the right thumb for two months and snapping for one month when first seen. Local injection of hydrocortone failed to give relief. Six months later, the thumb was still snapping and had almost locked in extension at times. A woman, who had had symptoms of pain for two months and snapping for one month, gradually recovered from pain, and the symptoms of snapping disappeared five months later. She was still symptom-free six months later when examination revealed some prominence of the nodule on the volar surface of the metacarpophalangeal joint, which was not tender. Another patient with symptoms of snapping recovered after several months without operation and has remained symptom-free for six years. Two patients with snapping thumbs did not return for follow-up care.

STENOSING TENOVAGINITIS OF THE SECOND, THIRD, FOURTH, AND FIFTH FINGERS

In nineteen patients, twenty-eight fingers other than the thumb were treated. Two of these had previously had thumb involvement and were included in the statistics on thumbs. In sixteen cases, the right side was involved (index finger in three, middle finger in five, ring finger in seven, little finger in one), and in twelve cases the condition occurred on the left (index finger in five, middle finger in three, ring finger in two, and little finger in two). In sixteen cases, the condition involved one finger only. Three cases were bilateral (middle finger on both hands in one case; the right second, third, and fifth fingers and the left second finger in another; and in the third patient all fingers of the left hand, including the thumb, and the right second and third fingers were involved).

An analysis was made of several studies concerning a significant number of cases in which the condition occurred in the thumb and in other fingers. An average was taken with respect to various factors of the cases reported here and those reported by other authors, in order to arrive at a more accurate percentage than would otherwise be available.[17, 19, 23] The thumb was involved more frequently (56.1 per cent.) than the lesser fingers.[17, 19, 23] The relative frequency of involvement in the lesser fingers is 39.3 per cent. in the ring finger, 38 per cent. in the middle finger, 12.7 per cent. in the little finger, and 10 per cent. in the index finger.[17, 19] These involvements of the lesser fingers occurred more frequently in females than in males (53.8 per cent.).[17, 19] The right side was predominantly involved in 64.5 per cent., and in 12.3 per cent. the condition occurred bilaterally.[17] Two or more of the lesser fingers were involved in 15 per cent.[17]

Only one child with a snapping finger other than the thumb was seen. Ninety-three cases involving the thumb in children, including our cases, and two cases with other finger involvement, in addition to our case, were found in the literature — an incidence of 3.1 per cent. of fingers other than the thumb in children. One of these cases involved the middle finger.[18] Watson-Jones reported a case of a child, four years of age, who had involvement of all eight fingers. Another type of triggering, that which is associated with passive extension in cases where the lateral portion of the tendon snaps back from the side to the dorsal aspect of the proximal joint when there is avulsion of the middle slip of the extensor tendon, has been described.[29] Sick reported the case of a young girl in whom a snapping of the right index finger developed as a result of trauma from a piece of glass. While two of our adult patients with thumb involvement subsequently had snapping of one or more of the lesser fingers, the association of thumb or finger involvement with de Quervain's syndrome was not observed by us. However, Resche [9], Troel [9], and Aitken each observed two cases in which de Quervain's syndrome was associated with stenosing tenovaginitis of either the thumb or the finger.

ETIOLOGY

Various theories have been advanced regarding the etiological factors, but a satisfactory explanation has not been given for trigger-finger in children. The history is frequently of little help in determining the age of onset.[15] The infant holds the thumb in a clenched position and the deformity may not become obvious until grasping appears.[30] While symptoms in some

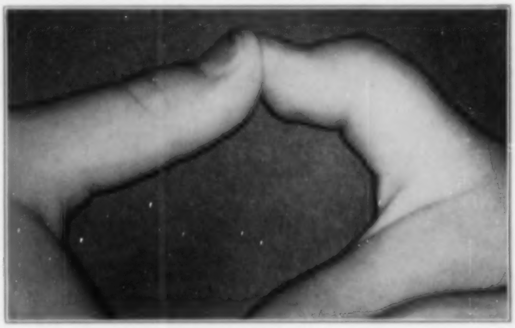

Fig. 1-A

C. H., Case 1. Shows the flexion deformity of the left thumb in a seven-year-old girl.

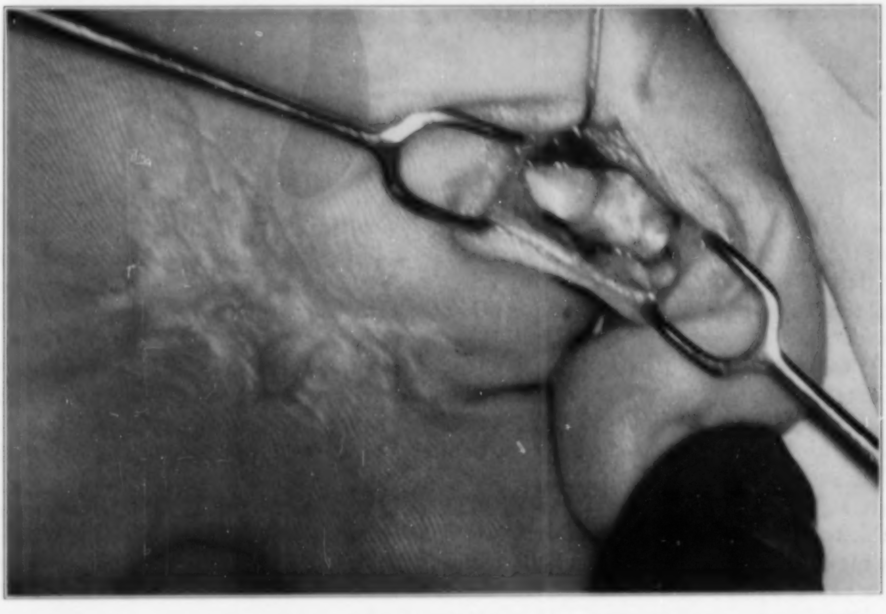

Fig. 1-B

Reveals the thickened digital fibrous sheath blocking the tendon nodule of the flexor pollicis longus and preventing extension of the thumb. The scar on the palm was caused by a burn five years previously, at which time locking was first noticed.

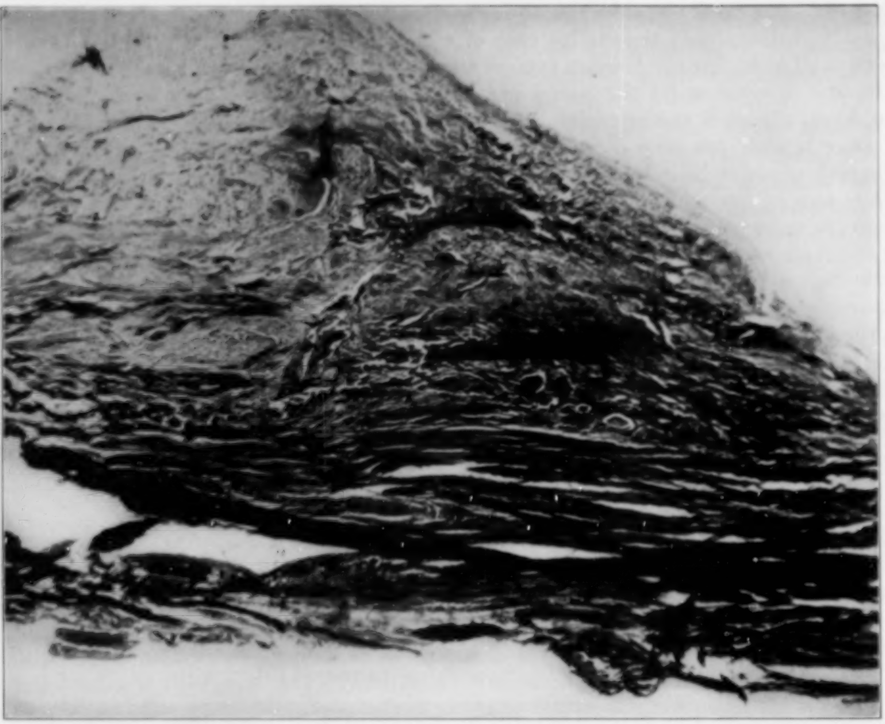

FIG. 1-C

Mallory aniline-blue staining of tissue from the tendon nodule. The light area above represents collagenous degeneration, while the dark area below shows the normal tendon fibers. [This section was magnified (× 20) with a Micro Tessar, 72 mm., F. 4.5 lens (Bausch and Lomb). This is a short focal length lens, used instead of a low-power microscopic exposure so that more of the specimen can be viewed.]

of the reported cases appeared to be present at birth [9,17,22,24,25] or very early in life, in most instances they were observed much later. It is likely that the onset is much earlier than the age at which symptoms become apparent to the parents. The flexed position of the thumb frequently found in infants [28] and thumb-sucking have been thought to be the initiating factors causing the deformity. Certain anatomical variations have been given consideration as an exciting cause.[30]

One author states that two of his patients had a hereditary history [30] and another author [14] found other congenital anomalies in association with one of his cases. However, there is only one specific instance that could be accepted as demonstrating familial incidence in the children reported. This occurred in twins (Figs. 5 and 6) previously reported by the authors.[3] A nineteen-month-old boy with a locked thumb who had a brother with bilateral involvement was reported by van Neck according to Falk.[9] We have been unable to verify this in the original article.[22] The occurrence at birth or shortly afterwards in some cases, the high incidence of bilateral occurrence in children, and the occurrence in twins points to a congenital background in children.

The appearance of trigger-finger in women of advanced age, the infrequent bilateral involvement, and the definite relation to trauma makes the etiology more understandable in the adult. The syndrome is frequently encountered in female manual workers in unaccustomed occupations or activities or in work which requires unusual or excessive activity

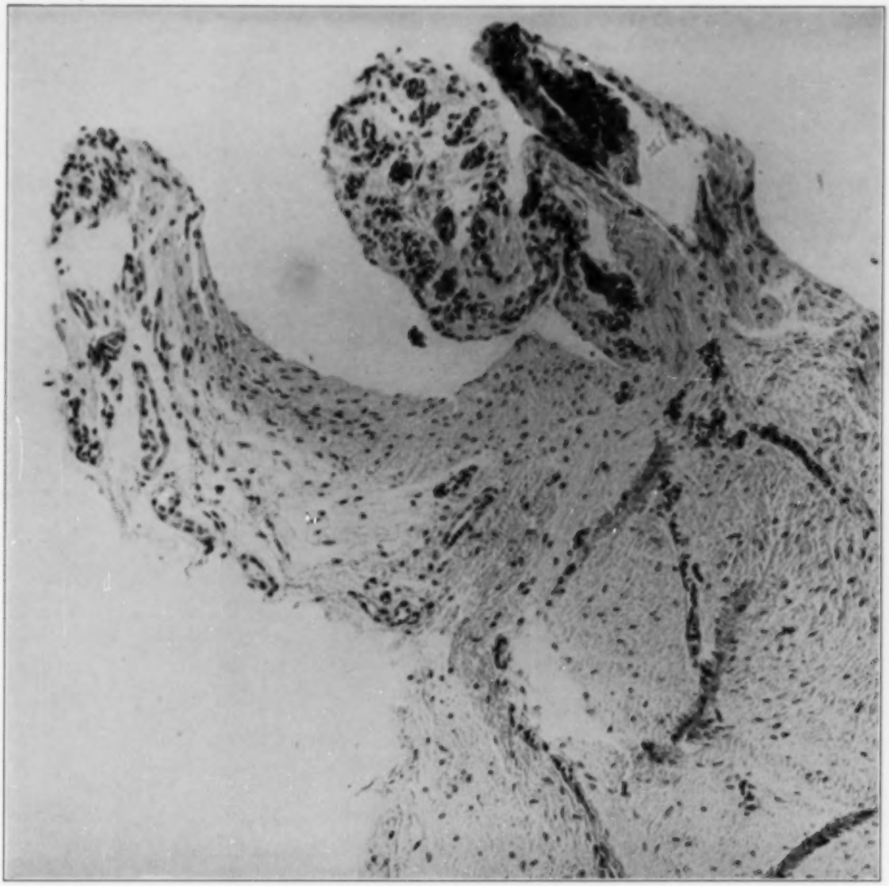

FIG. 1-D

Low-power photomicrograph of section of visceral synovial sheath over the nodule, showing villous proliferation with marked vascularization.

of the fingers. In three of our patients who worked on the same assembly line, this syndrome developed following excessive pressure exerted by the left thumb on a round cap in the process of inserting plastic tubes into the cap. One author found that the cause in three cases which he observed was an overheated arc-welding gun in two cases and over-exposure to an infra-red radiation lamp in the other case.[8] The frequency of the condition among untrained women welders has been pointed out.[21] Another author experimentally produced a snapping finger and a snapping thumb in his own hand by excessive flexion and extension against resistance.[28]

In most of our cases, there was no apparent relationship between the use of the thumb and the origin of the condition. The condition is more likely to develop in women in the older age groups because maximum degenerative changes are present. These factors, particularly in manual work, when excessive use of the fingers is required, give a plausible explanation. The relative immunity in the male is difficult to explain. Only one report concerning the possible hereditary basis in the adult could be found. Snapping-finger occurred in uni-ovular twins when they were about fifty-three years of age. They had an almost

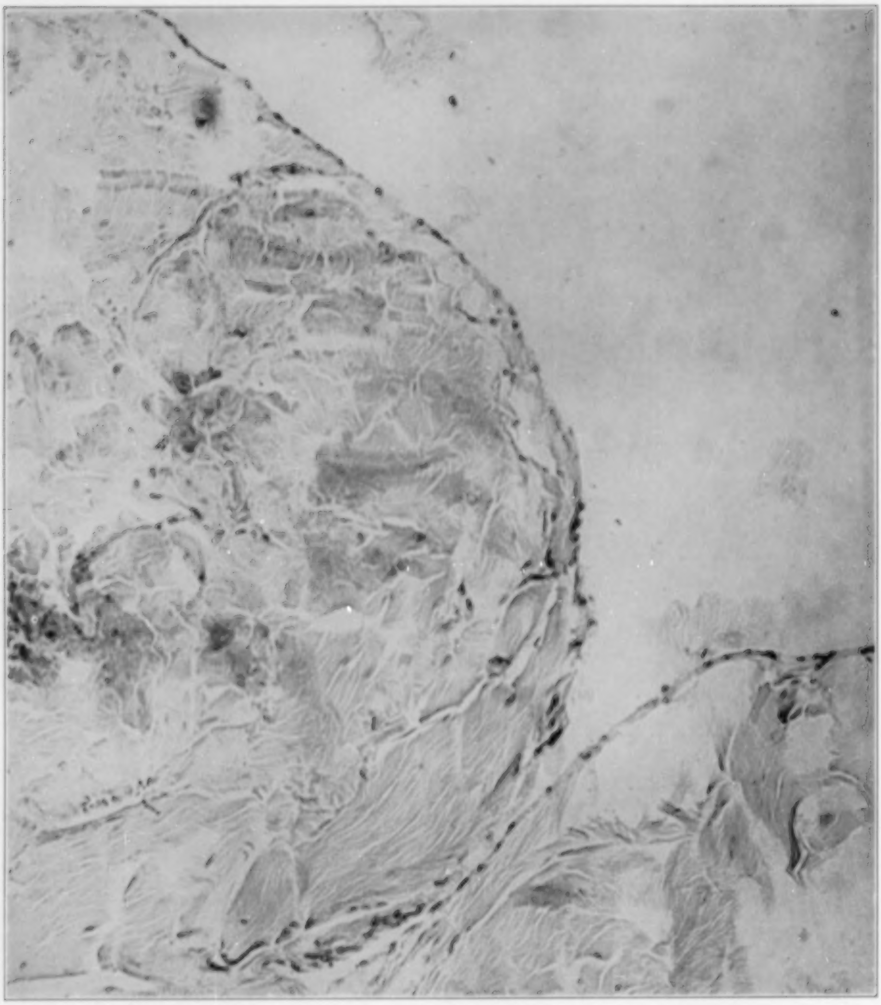

FIG. 2

Low-power photomicrograph of transverse section of the normal flexor pollicis longus tendon and its synovial sheath to show comparison with the thickened synovial layer in Fig. 1-D.

identical date of onset and symptoms, with involvement of the right ring finger in one twin and of the left ring finger in the other twin.[6]

SIGNS AND SYMPTOMS

When the thumb is involved in children, the condition is frequently confused with congenital contracture or dislocation, because the thumb is usually locked in flexion. The flexed position is the natural attitude in infants, and the most marked changes occur in the flexed tendon, proximal to the sheath, resulting in locking. The relative lack of voluntary control in the weak extensors, as compared with the flexors, may contribute to this deformity. When the thumb is locked in flexion, even passive motion is not sufficient to bring about extension. Flexion may be free and within the normal from the point of locking.

While in children the thumb is frequently locked in flexion, snapping is the most common symptom in the adult, and, when locking occurs, it is most frequently in extension. Locking in this position has been erroneously diagnosed as hysterical paralysis.[31] Burman described three cases of locking of the thumb in extension and thought it differed from the usual ball-like thickening of the tendon sheath in that it was an adhesive form of tenovaginitis more frequently caused by direct trauma and resulting in extension contracture and inability to flex the thumb. It appears that, when locking occurs in either children or adults, it is predominantly in the position of a natural attitude.

The nodule on the volar aspect of the thumb in the region of the metacarpophalangeal joint is firm and blunt in the adult and, for the most part, is the thickened digital fibrous sheath. This nodule may be painful on palpation, especially in the fingers other than the thumb,

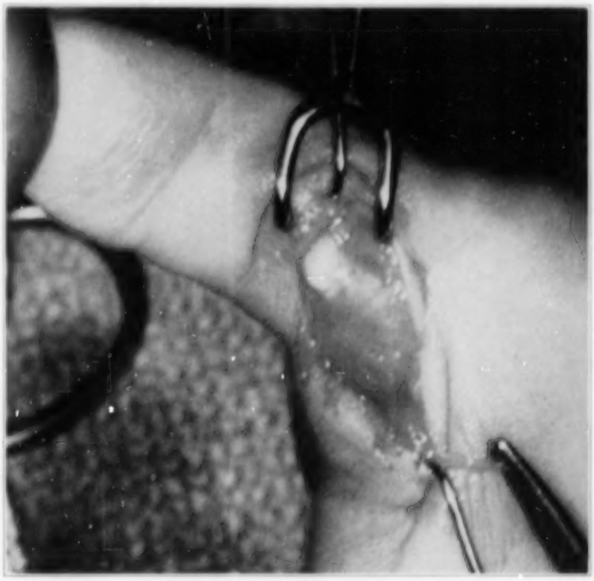

Fig. 3-A

Fig. 3-A: C. D., Case 2. Shows the tendon nodule locked against the distal portion of the thickened digital fibrous sheath in a five-year-old girl, thus preventing flexion and producing locking in extension of the thumb. (Reproduced by permission from *The Journal of Pediatrics*, **41**: 447, 1952.)

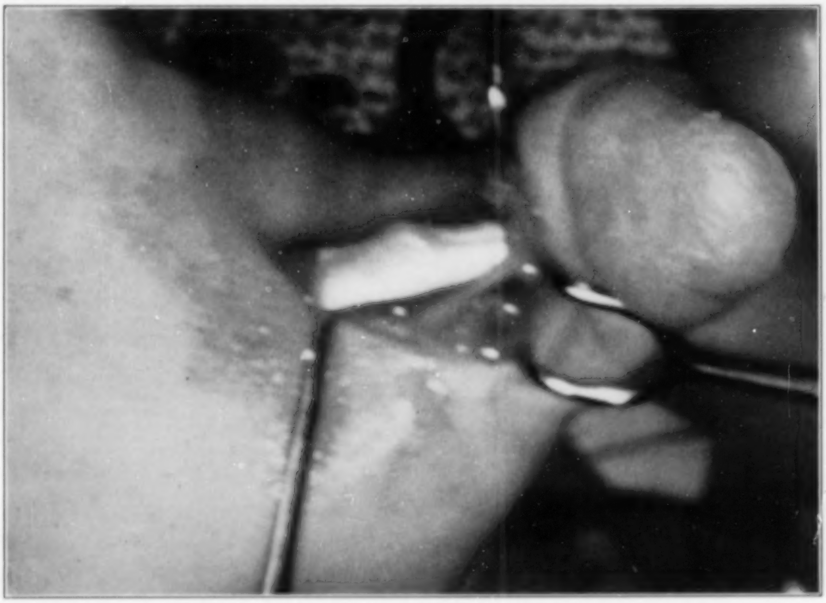

Fig. 3-B

Following excision of the tendon sheath, the tendon nodule was more clearly demonstrated. (Reproduced by permission from *The Journal of Pediatrics*, **41**: 448, 1952.)

and on forced extension may produce blanching of the skin and cause discomfort or pain. When the snapping phenomenon is present, pain is frequently experienced in the region of the nodule or the interphalangeal joint. Observation during surgery showed that movement of the tendon prominence through the stenosed sheath only slightly increased the size of the palpable mass. Two of our adult patients had a double snapping in both flexion and extension and, at operation, irregularities were found at two places in the tendons at points consistent with the points at which snapping had occurred.

Difficulty in extension or flexion of the finger may be the first symptom. It is more marked on awakening and tends to improve during the day. Snapping or clicking may occur later or it may be the initial symptom. Adults usually complain of discomfort or pain and enlargement at the base of the thumb in the region of the nodular, thickened digital fibrous sheath. The complaint of pain and clicking may be referable to the interphalangeal joint of the thumb and particularly noticeable

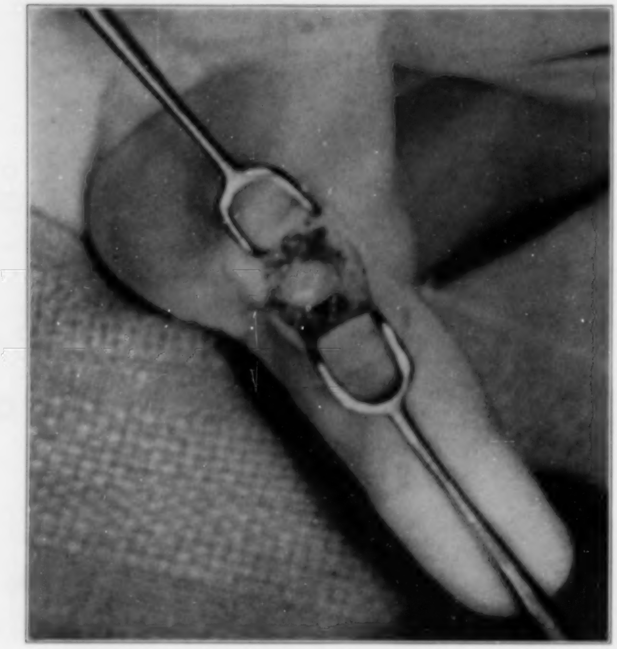

FIG. 4-A

Fig. 4-A: R. W., Case 3. Shows a ganglion exposed in the region of the metacarpophalangeal joint of a four-year-old boy who had a snapping right thumb for two and one-half years.

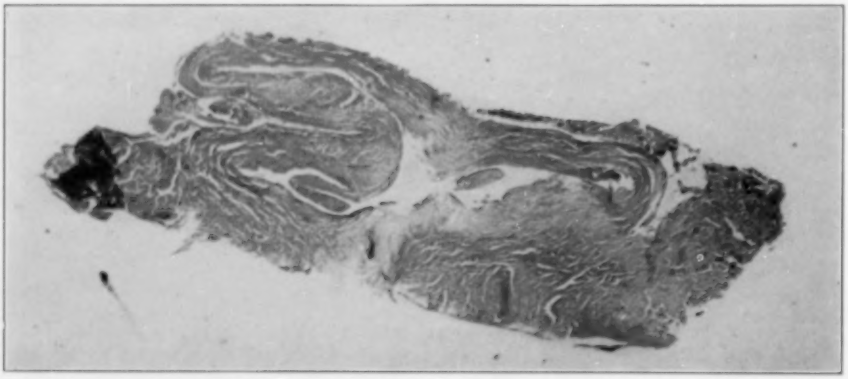

FIG. 4-B

Photomicrograph (× 23) of the ganglion in Case 3, which originated within the volar portion of the digital fibrous sheath of the flexor pollicis longus tendon. After the escape of the gelatinous material, the ganglion collapsed as shown.

when snapping occurs as the disproportionate tendon passes through the stenosed tendon sheath. The tendon sheath blocks entrance of the tendon enlargement momentarily, either in flexion or extension, following which the tendon passes abruptly through the tunnel. If there is a more marked disproportion in size, locking occurs and passive motion is necessary to overcome the resistance. Some patients use the other hand to force the finger into extension or flexion. In more advanced cases, even passive aid may be insufficient to move the nodule past the constriction.

In children, the palpable nodule at the base of the thumb was frequently the tendon nodule which moved as the distal phalanx was flexed or extended. In one case, however, it was found at operation (Case 1, Fig. 1-B) that, even though the tendon nodule was prominent, it was only a small part of the palpable mass at the base of the thumb which was made up for the most part of the grossly enlarged and thickened sheath.

In our adult patients, the nodule was not of sufficient size to be separately palpable from the digital fibrous sheath.

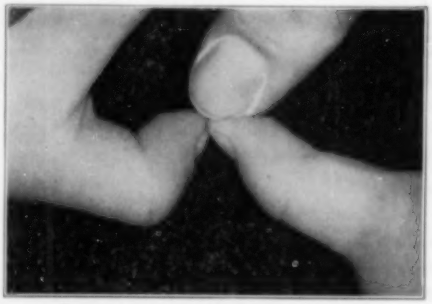

FIG. 5

J. N., Case 4. Shows bilateral flexion deformity in a three-year-old male fraternal twin.

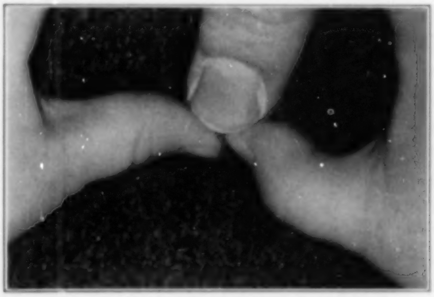

FIG. 6

J. N., Case 5. Illustrates flexion deformity of the right thumb in a three-year-old female fraternal twin.

PATHOLOGY

Considerable speculation has occurred regarding the primary site of the lesion and as to whether or not both the sheath and the tendon are involved concomitantly.

In adults, who are frequently seen and operated upon shortly after the onset of symptoms, the minimal changes in the tendon, as compared with those in the sheath, would indicate that the sheath is the principal factor producing the symptoms. The palpable firm nodule, which is located on the volar surface of the metacarpophalangeal joint of the thumb and in the distal portion of the palm when the fingers are involved, was found to be the markedly thickened digital fibrous sheath, which was sometimes two to three times the normal thickness. The sheath had lost its luster and had either a grayish oedematous appearance or that of a highly dense fibrous type of connective tissue. When a nodular or bulbous enlargement of the tendon was present, a definite constriction of the tendon was usually found proximal to or distal to the point of its junction with normal tendon. Changes less obvious than a nodular or bulbar formation were observed, such as alteration in the tendon by an accumulation of fibrous-like deposits, warty granulations, or generalized enlargement of the tendon.

The tendon involvement, such as collagenous degeneration and synovial proliferative changes, was more prominent as a rule in children. In some instances, the pathological changes in the digital fibrous sheath were minimal as compared with those in the adult, and the palpable nodule and either the snapping or the locking mechanism appeared to be due chiefly to the changes occurring in the tendon.

Microscopic examination of the tendon sheath showed varying degrees of degenerative changes and fibrous-tissue proliferation. The degenerative changes consisted in splitting or fraying of the fibers, colliquative degeneration, with formation of pseudocysts which contained a precipitate of protein-like material, and finally true cyst formation or ganglion, as occurred in one of our patients (Figs. 4-A and 4-B). Synovial or villous proliferative changes are commonly encountered (Fig. 8). Non-specific inflammatory changes, such as lymphocytic and plasma-cell infiltration, were not uncommon. Young vascular connective tissue and more mature fibrous tissue which at times was hyalinized were seen (Fig. 9). Chondroblasts and cartilage formation have been mentioned by a number of authors.[9,15,18]

Proliferation of the visceral synovial sheath of the tendon, in one instance, produced villus-like projections which were highly vascularized (Fig. 1-D). The tendon itself, in this case, showed a purer type of collagenous degeneration (Fig. 1-C). Some cases occasionally showed a few lymphocytes and histiocytes, evidence of a minimal inflammatory reaction.

Only one case of snapping-finger with a ganglion of the digital fibrous sheath was encountered (Fig. 4-A). It was interesting to speculate on the relationship of the pseudocyst formation shown in Figure 7-B to true ganglion formation which occurred in this case. Ganglia may arise from the tendon sheaths and joint capsules without communicating with the cavities.[6] The connective tissue undergoes proliferation resulting in a mucoid degeneration with the formation of numerous small cysts which finally collect to form a ganglion having little or no synovial lining. Others feel that ganglia occasionally have cysts lined with well defined synovial membrane which are filled with clear mucous fluid; these ganglia presumably represent a herniation of the synovial membrane from a joint space or a sheath space.[2]

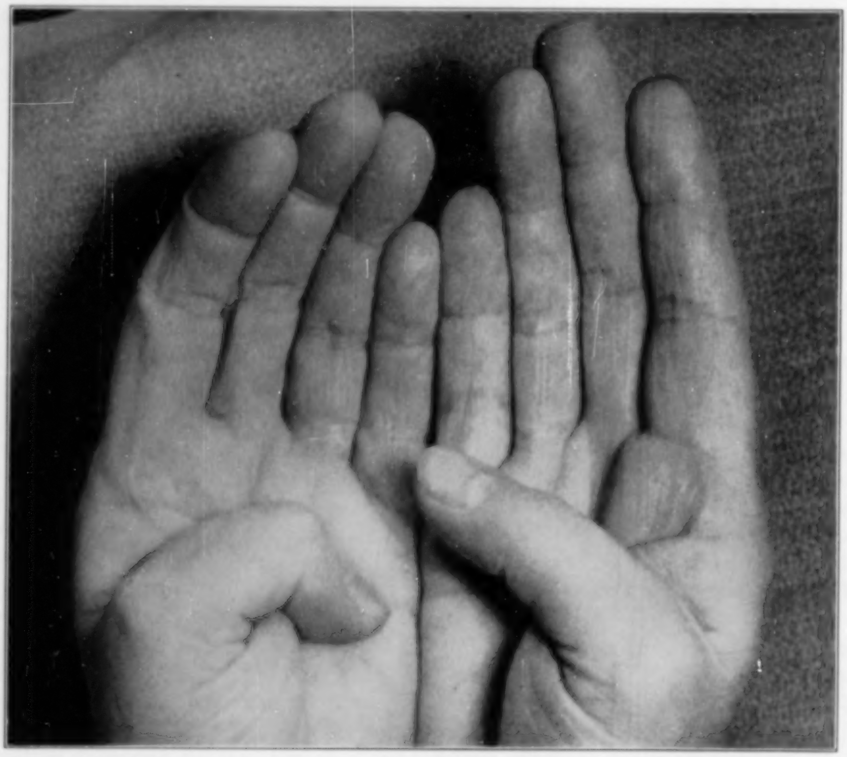

Fig. 7-A

C. K., Case 7. The appearance of the right thumb in a fifty-two-year-old woman, which had been locked in extension for two months.

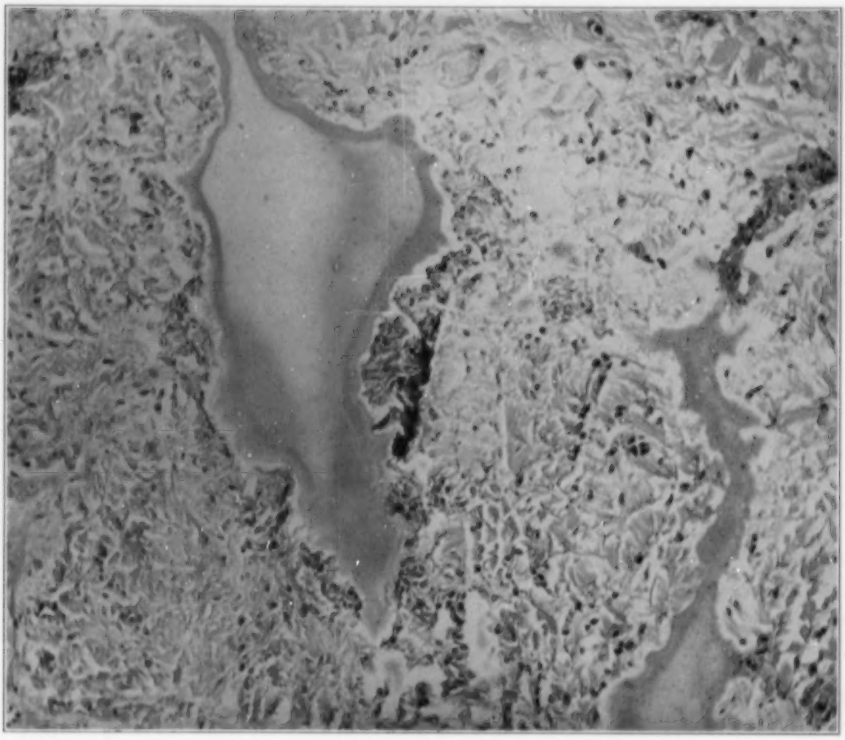

Fig. 7-B

Low-power view (× 75) of the digital fibrous sheath, revealing areas of colliquative degeneration.

TREATMENT

The conservative measures employed in children, such as immobilization and passive stretching, have been almost uniformly unsuccessful. One author reported successful results with two cases following stretching with a splint.[24] However, Jahss warns against prolonged passive stretching because of the possibility of producing hyperextension of the metacarpophalangeal joint. Lapidus reported one case in a child who, he believed, recovered spontaneously. He was not able to verify this by personal observation but, according to the child's mother, the child was symptom-free seven years later.

The average time that the deformity persisted following its first recognition and before operation in the thumbs in the cases of children reported here was 2.3 years. One child had had this deformity for five years before operation.

Compere reported a twenty-year-old female with bilateral snapping-thumb which had been present since the age of three or four.

The twelve thumbs in ten of the children reported here, and practically all those reported in the literature, responded satisfactorily to surgical treatment. In a study by Lapidus of fifteen adult cases of snapping-thumb not operated upon, six were reported to have recovered spontaneously, and of twenty-three snapping fingers not subjected to surgery, only five were said to have recovered. One of our patients had two snapping fingers on the same hand. One finger was operated upon with complete recovery, while the untreated finger has persisted to snap for ten years and, at present, is becoming more difficult to move actively. Occasionally passive motion is necessary.

Some authors thought that adults with early symptoms should have a trial period of conservative treatment, such as roentgen therapy and splinting, but admit that surgery is

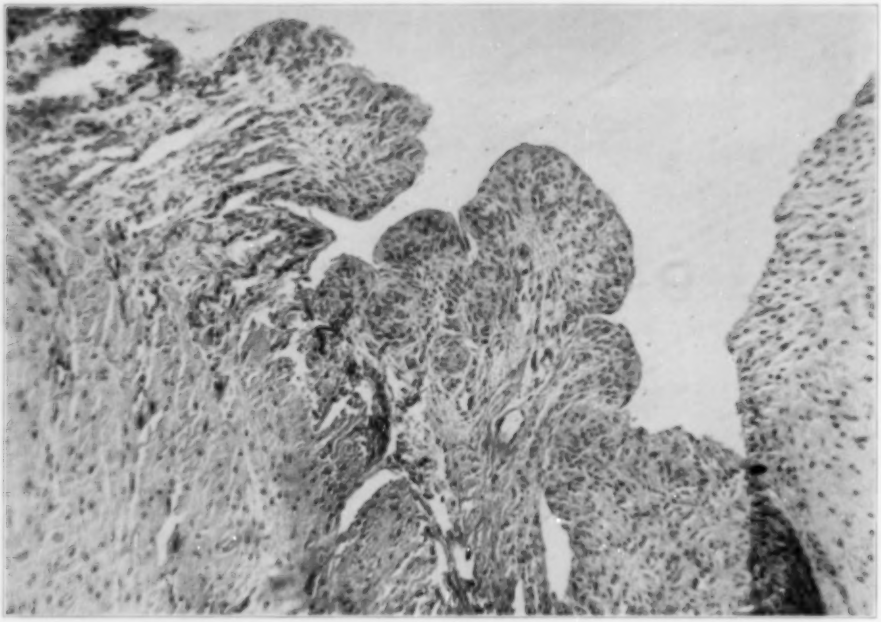

FIG. 8

F. B., a comptometer operator, forty-nine years old, had had a snapping right thumb for four weeks. Photomicrograph (× 21) of the synovial lining and adjacent tissue of the digital fibrous sheath showed micropapillary synovial proliferation and increased vascularization of the adjacent tissue.

usually necessary, particularly in cases of long standing.[19,21] Compound F, hydrocortone, has been reported to be effective in cases of trigger-finger, but the drug can in no sense be considered a cure.[13] Prolonged conservative treatment is unreliable and expensive.

Most authors who performed sheath incision did not specify where the incision should be made.[9,12,14,15,16] Lapidus did not believe it was important whether the incision of the sheath was made centrally or on one side as had been advocated.[4,28] Graham has reported successful treatment of snapping fingers other than the thumb by a puncture incision and section of the tendon sheath. In his opinion, this simplifies the operative procedure.

Local excision of the sheath removes much of the involved tissue, permits pathological study, and has impressed us as being a more reliable method than sheath incision. We did not observe bow-stringing following local excision of the sheath. Local anaesthesia is used in the adults and the more cooperative children. A transverse incision is made parallel to the proximal flexor crease of the thumb over the metacarpophalangeal joint, care being taken to avoid injury to the volar digital nerves which are more volarly placed than one would suspect. The thickened digital fibrous sheath is excised and the tendon enlargement is not disturbed, except for the removal of tissue for microscopic study. The skin is closed with a fine interrupted suture. Splinting is unnecessary and active motion is encouraged. When fingers other than the thumb are involved, the incision parallels the distal crease of the palm of the hand, or is made parallel to the longitudinal creases distal to the distal palmar crease.[17]

ILLUSTRATIVE CASES

CASE 1: C. H., a seven-year-old girl, had had a "contracture" of the distal phalanx of the left thumb for five years. At the age of two, the patient had burned the palm of the left hand, and it had been noticed at the changing of dressings that the thumb could not be extended. There was no history of snapping,

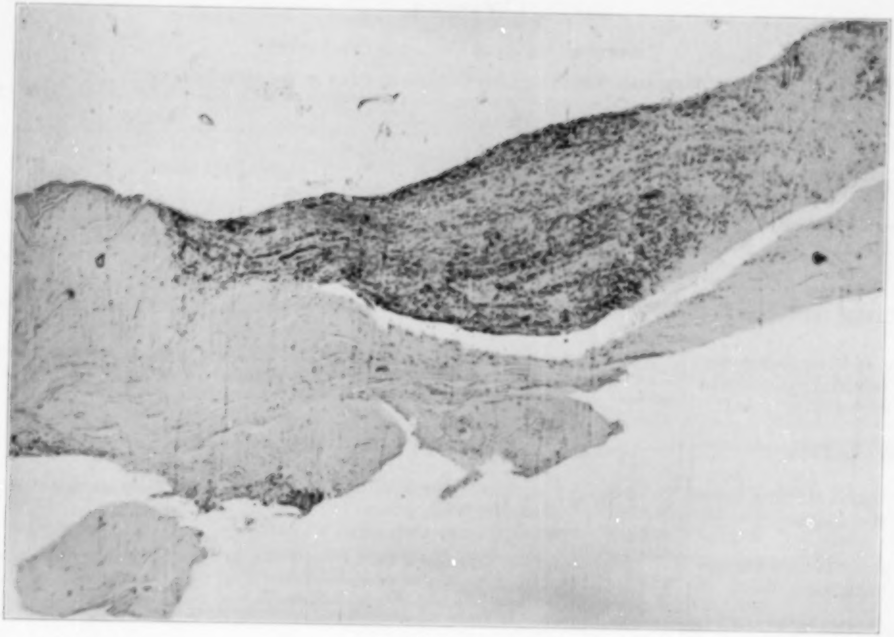

FIG. 9

Case 9. E. W., a sixty-year-old woman, had a double snap of the right thumb at 30 and 40 degrees from complete extension. Photomicrograph of the sheath (× 21) revealed an unusual localized proliferation of the young fibrous connective tissue from the synovial and underlying tissue.

trauma, or excessive thumb-sucking. A family history of this deformity was not elicited.

There was a scar on the palm of the hand, well away from the head of the first metacarpal. The distal phalanx of the thumb was locked in flexion at 150 degrees. Flexion was normal, but extension could not be accomplished even by passive motion (Fig. 1-A). A palpable, non-tender nodule at the base of the thumb did not move with motion of the thumb.

At operation, a thickened and constricted digital fibrous sheath was found (Fig. 1-B), as well as a nodule on the tendon, blocking the excursion of the tendon through the constricted sheath. The sheath was excised and tissue from the nodule was removed for biopsy.

Pathological examination of the digital fibrous sheath revealed dense fibrous connective tissue without inflammatory reaction. Mallory aniline-blue staining of the tendon nodule for collagen revealed collagenous degeneration (Fig. 1-C), and the synovial layer of the sheath showed villous proliferation with increased vascularization (Fig. 1-D).

Seven months postoperatively, the motion of the thumb was normal and the nodular enlargement was absent.

CASE 2: C. D., a five-year-old girl, had an extension deformity of the right thumb. The condition was noticed shortly following birth. At the age of two months, hot soaks and exercises had been instituted at a pediatric clinic because of a deformity of the left thumb. Snapping was one of the early symptoms observed by the parents. There was no family history of such a deformity and nothing to indicate that trauma might have been an etiological factor.

On examination, the thumb was fixed in extension with flexion limited to 150 degrees in both active and passive motion. A distinct mass was palpated on the volar surface at the metacarpophalangeal joint and another mass was palpable one centimeter distally. The distal nodule moved with the distal phalanx. The proximal nodular enlargement was the thickened digital fibrous sheath.

Through an incision at the proximal flexor crease, the constricted and thickened digital fibrous sheath which had produced the nodular mass at the base of the thumb was exposed. There was a prominent tendon nodule which blocked flexion by impinging against the distal edge of the sheath (Fig. 3-A). The thickened sheath was excised, freeing the tendon nodule (Fig. 3-B).

Nine months postoperatively, examination revealed normal motion and the absence of the nodule at the base of the thumb.

TABLE I

AUTHORS' CASES OF CHILDREN AND ADULTS
WITH STENOSING TENOVAGINITIS INVOLVING FLEXOR POLLICIS LONGUS

	Children	Adults
No. of patients	12 (27.9 per cent.)	31 (72.1 per cent.)
No. of thumbs	15	34
Left	9 (60 per cent.)	16 (47.1 per cent.)
Right	6 (40 per cent.)	18 (52.9 per cent.)
Bilateral involvement	3 patients (25 per cent.)	3 patients (9.7 per cent.)
No. of lesser fingers involved in patients seen during same period	1 (6.3 per cent., as compared with thumbs)	28 (45.2 per cent., as compared with thumbs)
Age when seen	17 mos. to 8 yrs. (average, 4 yrs.)	29 yrs. to 73 yrs. (average, 52 yrs.)
Duration of symptoms before treatment	1 day to 5 yrs. (average, 2.3 yrs.)	2 wks. to 2 yrs. (average, 2.6 mos.)
Age of onset when symptoms first noticed	Birth to 4.5 yrs. (average, 2.4 yrs.)	2 wks. to 2 yrs. before age when seen.
Sex		
Female	7 (58.3 per cent.)	All females (100 per cent.)
Male	5 (41.7 per cent.)	
Presenting deformity	11 (73.3 per cent.) locked in flexion.* 2 (13.3 per cent.) snapping in both flexion and extension. 1 (6.7 per cent.) flexed but could be extended passively and flexed actively. 1 (6.7 per cent.) locked in extension.**	28 (82.4 per cent.) snapping in both flexion and extension (in 2 of these, there was a double snap). 5 (14.7 per cent.) thumb in extension with loss of active flexion beyond 10 to 15 degrees. In 3 cases, force produced more flexion (in 1, full flexion), and the thumb sprang back into extension when the pressure was released and was not accompanied by a snap. In 1 case, passive force produced snapping in both flexion and extension. In 1 case, passive force produced flexion with snapping and then the thumb could be actively extended with snapping. 1 (2.9 per cent.) thumb in flexion required passive help to extend but could be actively flexed.
No. of patients with thumb involvement in whom snapping subsequently developed in the lesser fingers	None	2 (in 1 case, in opposite index finger; in 1 case, multiple involvement of fingers on both sides).

* Locked in flexion. Extension not possible even with passive aid. Flexion may be normal from point of locking.

** Locked in extension. Flexion blocked even to passive aid. Extension from point of block may be normal.

TABLE I *(continued)*

	Children	Adults
Trauma	Questionable	In some cases, a definite relationship exists. Three of the cases occurred in patients who worked on the same assembly line inserting caps into plastic tubes which involved using the left thumb.
Family history	Two of the patients were twins.	None.
No. of thumbs operated upon	12 thumbs in 10 patients	29 thumbs in 26 patients.
Pathology	Separately palpable tendon nodule frequently present at base of thumb.	Blunt nodule at base of thumb is, for the most part, thickened digital fibrous sheath. Tendon changes less prominent than those in children.
	Proliferative changes in visceral synovial layer of tendon sheath and degenerative changes in tendon are prominent, producing nodular formation.	Thickened stenosed sheath with collagenous and colliquative degenerative changes. Synovial and villous proliferation prominent.
	Gross and microscopic changes in sheath are, in some instances, minimal, in others, similar to sheath changes in adults.	Young fibrous tissue and more mature fibrous tissue with hyalinization. Mild non-specific inflammatory changes.
Treatment	Only operative treatment satisfactory: Local sheath incision; Early active motion.	Conservative treatment may be tried for a few weeks (observation, physical therapy, splinting, x-ray). Operative treatment for cases seen late or those not responding to conservative treatment. (Same operation as for children.)
Results	Results have been good in all cases when surgery was performed. Normal function and no complaints.	All but 2 of the 26 patients who had 29 thumb operations had good results without complications. (In 1, superficial wound infection developed which responded to treatment; another had some limitation of flexion and numbness of the volar surface of the thumb.)

CASE 3: R. W., a four-year-old boy, had first demonstrated difficulty at one and one-half years of age when the mother had noticed that the child could not straighten his right thumb. A tumor had also been noticed at the base of the thumb at this time. The patient had been taken to a physician who had splinted the thumb in extension for three weeks. Soon after the discontinuance of splinting, the thumb began to snap, with pain occurring over the nodule. No history of thumb-sucking or trauma was elicited, and there was no family history of this deformity.

Examination revealed a large obvious nodule on the volar aspect of the right thumb at the metacarpophalangeal joint, which caused blanching of the skin. This mass, approximately one centimeter in diameter, was not tender and did not move with motion of the thumb. Snapping was present on extension and flexion, both active and passive, occurring at 150 degrees.

Surgery was carried out under local anaesthesia through a flexor-crease incision. A ganglion (Fig. 4-A) was encountered, which originated within the volar portion of the thickened digital fibrous sheath and which did not communicate with the synovial space. A bulbous nodule on the flexor tendon was found proximal to a thickened and constricted sheath which blocked extension. The sheath was excised. The tendon moved freely following excision of the sheath and ganglion. Only the skin was closed with fine nylon suture.

Pathological examination of the sheath revealed that the ganglion occupied the volar two thirds of the sheath. The inner portion of the sheath was dense fibrous connective tissue (Fig. 4-B) without inflammatory changes.

Examination three months after operation revealed that the motion of the right thumb was normal.

Case 4: J. N., a three-year-old male, a fraternal twin, had had a flexion deformity of the distal phalanx of both thumbs (Fig. 5) for approximately one year. Snapping had never been present in the right thumb, but it was thought to have been present on a few occasions in the left. There was no history of trauma or thumb-sucking. The fraternal twin had unilateral snapping-thumb (Case 5, Fig. 6).

Examination revealed flexion deformity of the distal phalanx of both thumbs with extension limited actively and passively at 140 degrees. A mass was palpated on the volar aspect of the thumb in the region of the metacarpophalangeal joint.

Surgery was performed bilaterally through the flexor-crease incision. There was a bulbous tendon enlargement on the flexor pollicis longus tendon, proximal to a thickened and constricted digital sheath. The sheaths were excised and the skin was closed with fine nylon suture.

Pathological examination of the sheaths showed dense fibrocollagenous tissue without inflammatory reaction.

Function was normal twenty-three months postoperatively.

Case 5: J. N., a three-year-old girl, a fraternal twin, had had a flexion deformity of the right thumb for about one year with no snapping noted (Fig. 6). A nodule was noticed on the base of the thumb which blanched on attempted forced extension. There was no history of trauma or thumb-sucking. Her fraternal twin had bilateral flexion deformity of the thumb (Case 4, Fig. 5).

Examination revealed a flexion deformity of the distal phalanx of the right thumb at 140 degrees. Extension was blocked actively and passively at 140 degrees; flexion was normal. A mass was noticed on the volar aspect of the metacarpophalangeal joint, with moderate pain and blanching of the skin over the mass occurring on attempted extension.

Surgery through a flexor-crease incision revealed a nodule on the flexor tendon which was blocked by a thickened and constricted sheath. Excision of the tendon sheath released the tendon and permitted free extension. The skin was closed with fine nylon suture.

Pathological examination of the sheath showed dense fibrocollagenous tissue without inflammatory reaction.

Function was normal twenty-three months postoperatively.

Case 6: D. H., a twenty-month-old boy, was brought in for examination after his mother had noticed that she could not straighten the child's right thumb. There was no snapping present, and the thumb was fixed in flexion. There was no family history of this deformity and no history of trauma or thumb-sucking.

Physical examination revealed a flexion deformity of the distal phalanx of the right thumb with extension limited to 135 degrees, both in active and passive motion. Flexion was complete, actively and passively. A thickening, which did not move with motion of the phalanx, was felt through the skin on the volar aspect of the base of the thumb.

Surgery was carried out through the flexor-crease incision. Under general anaesthesia, the thumb could be extended with an accompanying "snap". A thickened and constricted digital fibrous sheath was found. Changes in the tendon were minimal with a localized area of loss of luster and whitish thickening proximal to the constricted sheath. The sheath was excised in a longitudinal segment and the tendon was free in its excursions.

Pathological examination of the sheath revealed dense fibrocollagenous tissue without evidence of inflammatory reaction. Only the skin was closed with fine nylon suture.

Examination six months postoperatively revealed normal function; the nodule was not felt, and the scar was minimal.

Case 7: C. K., a housewife, fifty-two years old, had noticed snapping of the right thumb three months prior to admission. Shortly following the onset of symptoms, passive motion was required in order to flex the thumb. For two months prior to admission, the thumb had been locked in extension.

On examination, the thumb was found to be locked in extension (Fig. 7-A), and flexion was limited to only 15 degrees of passive motion. A non-tender mass, which did not move with thumb motion, was palpated over the metacarpophalangeal joint.

Surgery was carried out through the flexor-crease incision and a thickened and constricted digital fibrous sheath was found. Distal to the constricted sheath was a white plaque thickening of the flexor tendon. The sheath was excised, and the tendon moved freely in its bed.

Pathological examination of the sheath revealed fibrocollagenous tissue with areas of degeneration and oedematous separation of fibers. There were areas of pseudocyst formation resulting from colliquative degeneration (Fig. 7-B) and minimal non-specific inflammatory reaction.

Examination three months postoperatively revealed normal motion of the right thumb.

CASE 8: M. D., a housewife, sixty-four years old, had first noticed difficulty in straightening her left ring finger three months prior to admission. She had had considerable pain along the finger when the snapping phase occurred. Certain types of housework, such as sewing, aggravated her symptoms.

Examination revealed that snapping of the left ring finger occurred at 120 degrees of flexion and extension by active and passive motion. A mass, which did not move with finger motion, was felt over the metacarpophalangeal joint.

Surgery was carried out through the distal palmar crease, and a thickened, grayish, oedematous, constricted sheath was found with small irregular granulations on the volar surface of the flexor tendon. The flexor tendons of the finger moved freely following local excision of the sheath.

Pathological examination of the sheath revealed fibrocollagenous tissue with minimal scattered nonspecific inflammatory reaction. There were also multiple pseudocysts of colliquative degeneration which contained mucous material.

Examination of the left ring finger two months postoperatively revealed normal motion, and the mass was no longer felt at the metacarpophalangeal joint.

CASE 9: E. W., a sixty-year-old woman, had had symptoms for three months, beginning with soreness and a lump at the base of the right thumb. Two months later, snapping in both flexion and extension began. She also complained of pain at the interphalangeal joint, especially on snapping.

Examination revealed a nodular mass at the base of the thumb which was painful on motion of the finger. There were two distinct snaps at 30 and 40 degrees from complete extension. She stated that she worked in the packing department of a candy factory and that she had not noticed any unusual activity that would cause the present deformity.

The patient was operated upon through a transverse incision at the base of the thumb, and a thickened digital fibrous sheath was removed. There were two separate areas of tendon enlargement, covered with granulations, which accounted for the double snap. The thickened digital fibrous sheath was excised.

Microscopic examination revealed an unusual localized proliferation of the young fibrous connective tissue from the synovial and underlying tissue of the digital fibrous sheath (Fig. 9).

SUMMARY

A comparison of the incidence, etiology, symptoms, pathological variations, and treatment in adults and children with trigger-finger discloses some interesting facts.

The occurrence in twin children, previously reported by us[3], is one of the few instances of familial involvement.

The occurrence in twins, the appearance of the syndrome at birth or in early childhood, and the frequent bilateral involvement all lend support to the theory that children may have a congenital predisposition to trigger-finger.

The most frequent presenting deformity in children was locking in flexion, while in the adult, snapping was the most common complaint. Loss of active flexion, except for a few degrees, with the thumb held in extension, was the next most common presenting deformity in the adult. There was double snapping in both flexion and extension in two of our adults with involvement of the thumb. In the adult, digital-fibrous-sheath involvement is prominent and tendon changes are minimal, as compared with the condition in children. The palpable mass at the base of the thumb in children is frequently due to tendon proliferation and degeneration, which results in nodular formation.

Conservative management may be tried in adults who are seen shortly after the onset of symptoms. For adult patients who do not respond to conservative treatment and for those seen late, operative treatment is recommended. In children, only the operative treatment has been found to be satisfactory. Local excision of the tendon sheath, suture of only the skin, and encouragement of early motion have given satisfactory results.

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DISCUSSION

TRANSMETATARSAL AMPUTATION

(Continued from page 1199)

incidence of repeated involvement in patients who have gangrene limited to toes. There is a specific reason for that: If a patient has extensive peripheral vascular disease and if any one of his toes is ischaemic enough so that a mild factor such as a blister leads to gangrene, then I have good reason to believe that the rest of his toes are in a similar state, that a toe is a part of the anatomy in which it is practically impossible to develop any collateral circulation, and that the circulation in all toes is poor.

On the subject of sympathectomy, I likewise have little to say. Our knowledge of the indications for sympathectomy is still based entirely on clinical impression. I realize that this is a very efficient measure for the care of such conditions as intermittent claudication, but I still doubt that it is useful for gangrenous toes.

CAPSULECTOMY OF THE INTERPHALANGEAL JOINTS OF THE FINGERS *

BY RAYMOND M. CURTIS, M.D., BALTIMORE, MARYLAND

The surgeon who is called upon to treat the crippled hand is frequently confronted with a hand which fails to function properly because of a limitation of flexion or extension in the interphalangeal joints.

Dr. Sterling Bunnell has pointed out that it is the narrow joint space present in the interphalangeal joints which produces limited motion when there is even the slightest shortening of the capsular ligaments, as might be produced by non-use or oedema of the ligaments and subsequent fibrosis. This shortening with limitation in motion may occur despite the most rigid attention to proper splinting and physical and occupational therapy. However, it more often follows the improper use of these methods of treatment.

MECHANICAL FACTORS LIMITING FLEXION AND EXTENSION OF INTERPHALANGEAL JOINTS

The surgeon who is to set about to correct a limitation of flexion or extension of the interphalangeal joints must have in mind the various anatomical structures within a finger which may limit this motion. These structures are listed in outline form below:

1. Limited flexion or extension contracture:
   a. Scar contracture of the skin over the dorsum of the finger;
   b. Contracted long extensor muscle or adherent extensor tendon;
   c. Contracted interosseus muscle or adherent interosseus tendon;
   d. Contracted capsular ligament, particularly the collateral ligaments;
   e. Bony block or exostosis.
2. Limited extension.
   a. Scar of skin on the volar surface of the finger;
   b. Contraction of the superficial fascia in the finger, as in Dupuytren's contracture;
   c. Contraction of the flexor-tendon sheath within the finger;
   d. Contracted flexor muscle or adherent flexor tendon;
   e. Contraction of the volar plate of the capsular ligament;
   f. Adherence of the collateral ligaments with the finger in the flexed position;
   g. Bony block or exostosis.

PREOPERATIVE CLINICAL EVALUATION

Before one sets out to correct by surgery the lack of flexion or extension of the interphalangeal joints, it is important to first determine by clinical examination and roentgenogram just which anatomical structures are limiting flexion or extension and to be certain that a true ankylosis by bony fusion is not present. Bunnell, Doherty, and Curtis have described various test positions into which one can place the hand and fingers in order to determine which structures are to blame. Figures 1, 2, and 3 illustrate and describe these test positions.

Test for Contracted or Adherent Long Extensor Tendons

In Figure 1, *A*, we see that, with the wrist in dorsiflexion and the metacarpophalangeal joints in extension, the fingers flex at the interphalangeal joints with ease. However, if the long extensor tendons to the fingers are adherent over the dorsum of the hand or if the extensor muscles have become shortened by fibrosis, we find, as in Figure 1, *B*, that, with the wrist and metacarpophalangeal joints volarly flexed, the interphalangeal joints are held in rigid extension.

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* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 22, 1954.

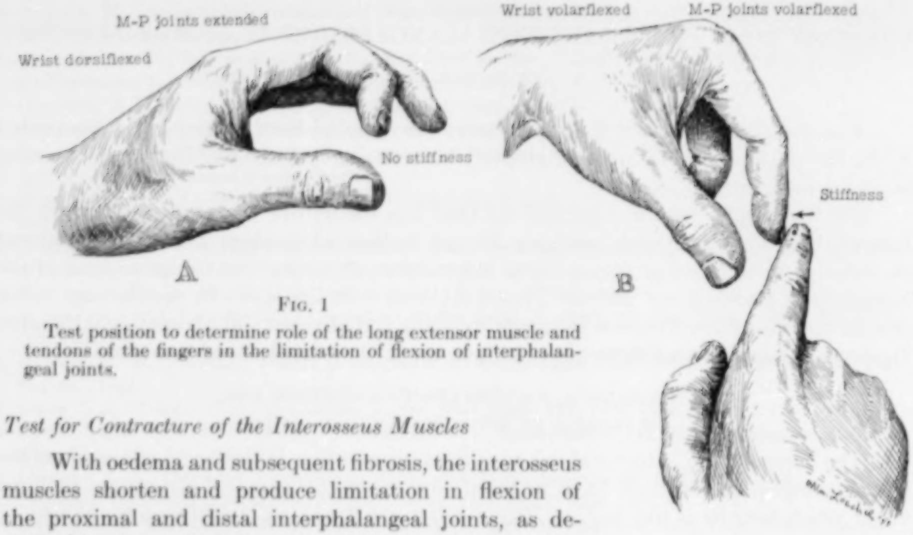
M-P joints extended
Wrist dorsiflexed
No stiffness
A
Wrist volarflexed
M-P joints volarflexed
Stiffness
B

Fig. 1

Test position to determine role of the long extensor muscle and tendons of the fingers in the limitation of flexion of interphalangeal joints.

Test for Contracture of the Interosseus Muscles

With oedema and subsequent fibrosis, the interosseus muscles shorten and produce limitation in flexion of the proximal and distal interphalangeal joints, as described by Bunnell, Doherty, and Curtis. This disabling syndrome is frequently associated with a contracture of the collateral ligaments of the interphalangeal joints.

The fingers usually assume one of two positions when there is a contracture of the interosseus muscles. The first has been said by Bunnell to resemble the hand "entering the sleeve of a coat",—that is, the fingers are held in rigid extension at the metacarpo-

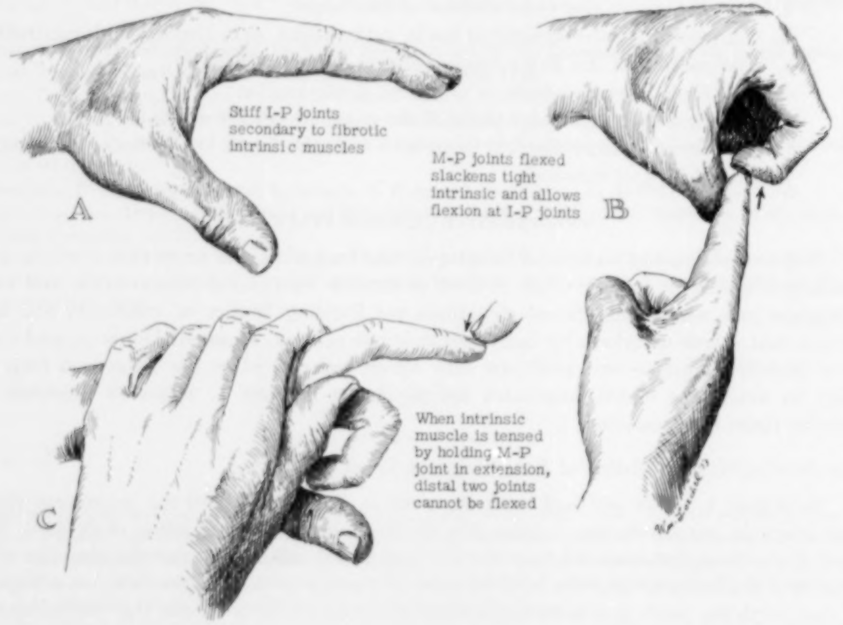
Stiff I-P joints secondary to fibrotic intrinsic muscles
A
M-P joints flexed slackens tight intrinsic and allows flexion at I-P joints
B
When intrinsic muscle is tensed by holding M-P joint in extension, distal two joints cannot be flexed
C

Fig. 2

Test positions to determine role of contracted interosseus muscles in the limitation of flexion of interphalangeal joints.

phalangeal as well as at the interphalangeal joints. The second group of cases show limitation of flexion at the interphalangeal joints but the fingers are held in rigid flexion at the metacarpophalangeal joints. In this latter group, the hand can be said to resemble a "blade of a hoe". The former is due to the fact that the contracture occurred while the hand was held or splinted in a position of extension at the metacarpophalangeal joints, while the latter, the position of flexion at the metacarpophalangeal joints, is assumed when the contracture has occurred while the metacarpophalangeal joints were immobilized or held in a position of acute flexion. This latter position allows the interosseus tendons to fall volarly and become adherent in front of the metacarpophalangeal joint. This same flexion deformity at the metacarpophalangeal joints is assumed if the volar interossei and the lumbricals are the major group to be contracted.

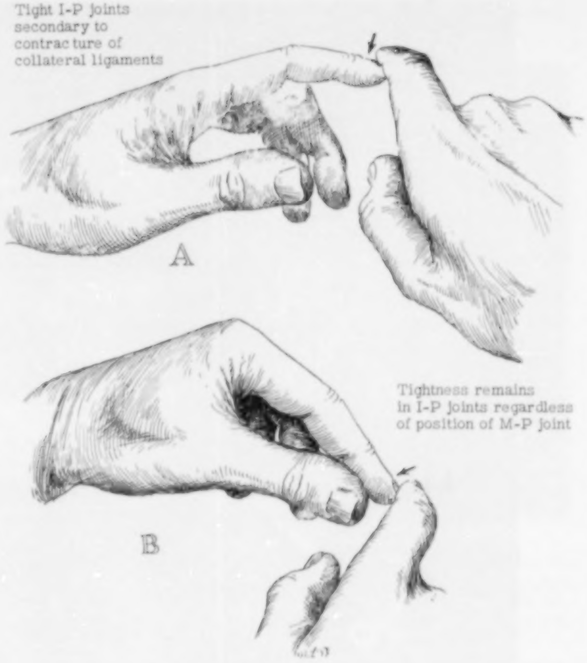
Tight I-P joints secondary to contracture of collateral ligaments
A
Tightness remains in I-P joints regardless of position of M-P joint
B

FIG. 3

Test positions to determine if the limitation of flexion at interphalangeal joints is due to contracted collateral ligaments. When the limitation is due solely to the collateral ligaments, the limitation remains the same regardless of position of finger.

The test for this contracture, demonstrated in Figure 2, has been described by Bunnell, Doherty, and Curtis. Clinically, we find on examination that there is flexion of the interphalangeal joints when the fingers are flexed at the metacarpophalangeal joints, but, as the fingers are forced into extension at the metacarpophalangeal joint and the contraction is accentuated, the interphalangeal joints cannot be forced into flexion.

Test for Contracture of Collateral Ligaments

This test is shown in Figure 3, which demonstrates that, when the limitation in flexion at the interphalangeal joint is due solely to the contracted collateral ligaments, there is no change in this limitation, regardless of whether the examiner flexes or extends the metacarpophalangeal joints.

Testing for Mechanics of Limitation in Extension

It is possible to use the same type of testing for the finger which lacks complete extension at the interphalangeal joints; however, one finds some difficulty in making such a clear differentiation as to the limiting factor. For example, clinically one has difficulty in distinguishing preoperatively a flexor tendon which is adherent over the proximal phalanx, a contracture of the flexor tendon sheath, a contracture of the volar plate of the capsular ligament, and collateral ligaments which have become adherent to the side of the phalanx and to the volar aspect of the capsule while the joint was held in a position of flexion.

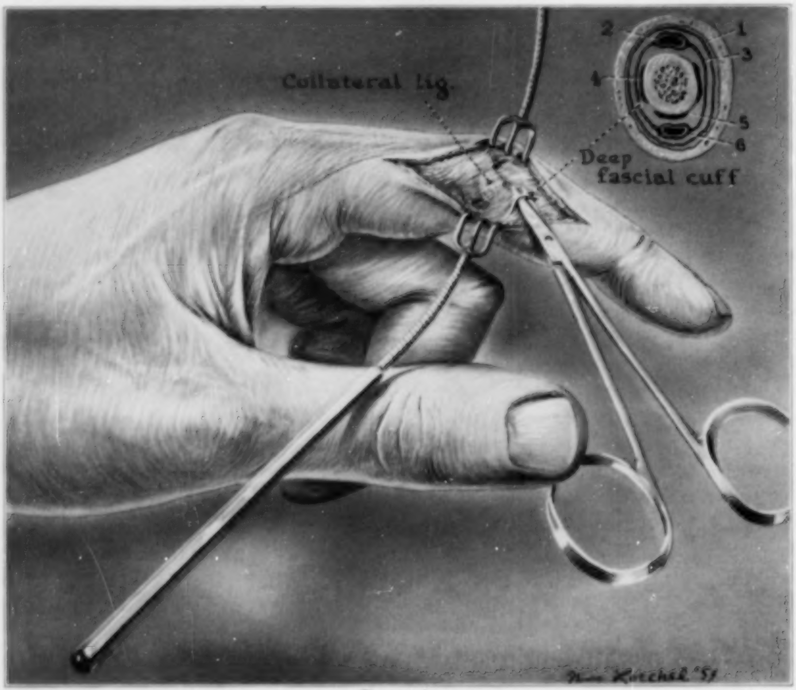
Collateral lig.
2
1
3
4
5
6
Deep fascial cuff

Fig. 4-A

Capsulectomy of proximal interphalangeal joint. Diagram shows operative approach for capsulectomy of proximal interphalangeal joint. Skin incision is developed down to deep fascial cuff, which is lifted with point of scissors to show approach to collateral ligament.

Inset shows cross section of finger at level of base of middle phalanx with deep fascial cuff extending from extensor to flexor.

1: Superficial fascia.
2: Extensor tendon.
3: Deep fascial cuff.
4: Collateral ligament of joint capsule.
5: Volar plate of capsule.
6: Flexor tendon.

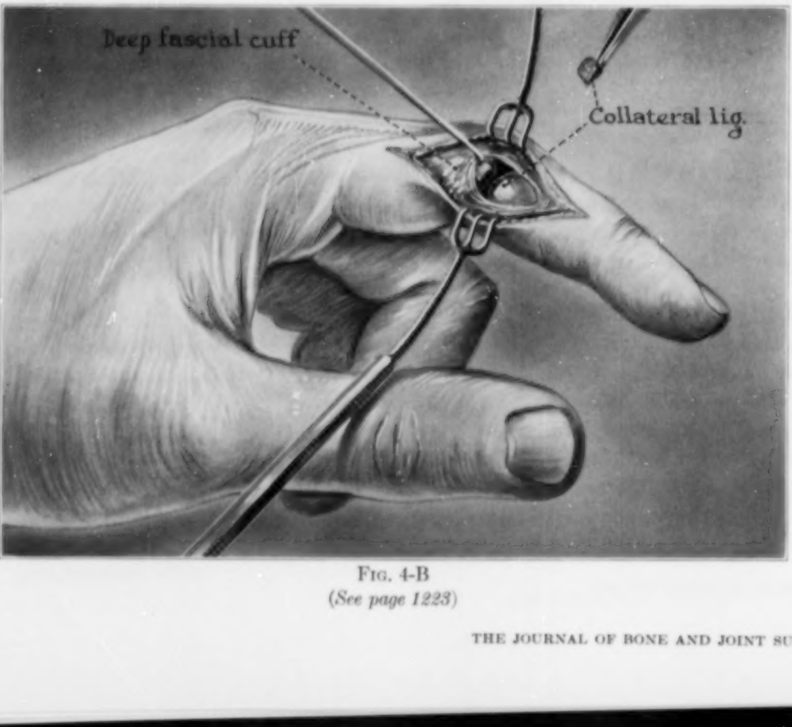
Deep fascial cuff
Collateral lig.

Fig. 4-B

(*See page 1223*)

Fig. 4-B: Capsulectomy of proximal interphalangeal joint. The deep fascial cuff has been retracted, and a block of collateral ligament has been excised.

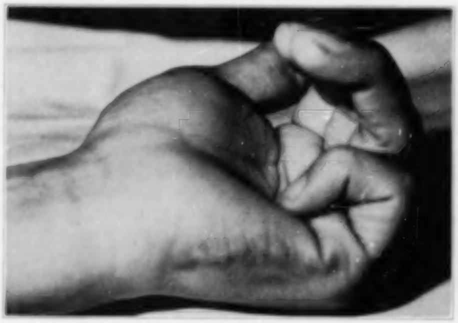

FIG. 5-A

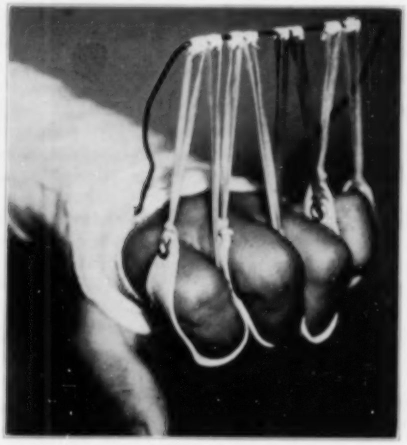

FIG. 5-B

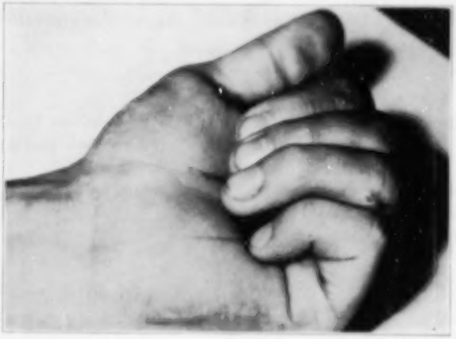

FIG. 5-C

Fig. 5-A: Case 1. Shows limitation of flexion due to tight collateral ligaments, contracture of interossei, and adherent flexor tendons, following fractures of proximal phalanges of index, middle, ring, and little fingers.

Fig. 5-B: Shows type of splint used postoperatively to stretch the interphalangeal joints into flexion and also to hyperextend the metacarpophalangeal joints to prevent recurrence of the interosseus contracture.

Fig. 5-C: Shows degree of improvement following capsulectomy of collateral ligaments, tenotomy of the interossei, and tendolysis of the finger flexors.

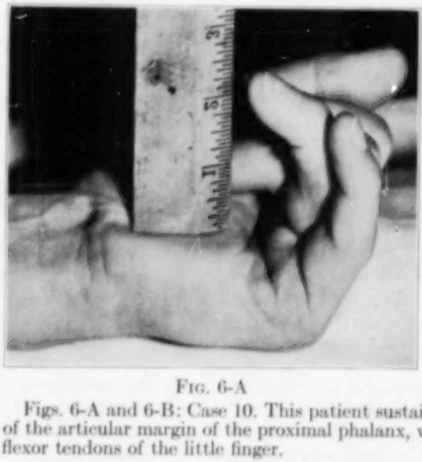

FIG. 6-A

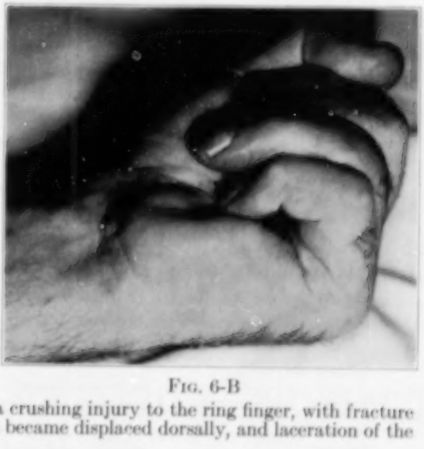

FIG. 6-B

Figs. 6-A and 6-B: Case 10. This patient sustained a crushing injury to the ring finger, with fracture of the articular margin of the proximal phalanx, which became displaced dorsally, and laceration of the flexor tendons of the little finger.

Fig. 6-A: Shows preoperative limitation of flexion in the ring finger due to stiff proximal interphalangeal joint, secondary to tight collateral ligaments and unreduced fracture of the articular margin of the proximal phalanx. The limitation of flexion in the little finger was due to adherent flexor tendons following primary repair.

Fig. 6-B: Shows improvement in flexion after reduction of fracture, and capsulectomy of the collateral ligaments and tendolysis of flexor tendons in ring and little fingers.

TABLE I

SUMMARY OF TWENTY-FIVE CASES OF CAPSULECTOMY OF INTERPHALANGEAL JOINTS FOR LIMITATION OF FLEXION

Case No.	Injury	Disability	Operative Procedures	Results
1	Fractures of proximal phalanges of the index, middle, and ring fingers.	Lacked on flexing to distal palmar crease: Index: 2½ in. actively, 1¾ in. passively; Middle: 3 in. actively, 2½ in. passively; Ring: 3 in. actively, 2½ in. passively.	Capsulectomy of proximal interphalangeal joints. Tenotomy of interossei. Tendolysis of finger flexors.	Flexes all fingers to distal palmar crease actively. Can claw fingers passively.
2	Fracture of proximal phalanx, index finger.	Malunion with angulation. Lacked: 1½ in. of complete extension; 1⅜ in. on flexing to distal palmar crease.	Capsulectomy of proximal interphalangeal joint. Tendolysis of extensor tendon. Osteotomy of proximal phalanx.	Lacks 1 in. of complete extension and ½ in. of complete flexion. Angulation corrected.
3	Crushing injury with fracture of proximal phalanx, middle finger.	Malunion with angulation. Lacked: 2 in. of complete extension; 1¾ in. on flexing to distal palmar crease.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Osteotomy of proximal phalanx.	Lacks 1 in. on flexing to distal palmar crease. No gain in extension.
4	Crushing injury with fracture of proximal phalanx, index finger.	Dense cicatrix with bone block, proximal interphalangeal joint. No motion at proximal interphalangeal joint.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Excision of exostosis from joint.	Gained 30 degrees of motion at proximal interphalangeal joint. Less pain with use of proximal interphalangeal joint.
5	Fractures of proximal phalanges of middle, ring, and little fingers.	Lacked 2 in. on flexing middle, ring, and little fingers to distal palmar crease. No active or passive flexion at distal interphalangeal joint. Not able to work.	Capsulectomy of collateral ligaments of proximal and distal interphalangeal joints. Tendolysis of flexor tendons. Tenotomy, interossei.	Actively flexes all fingers to 1¼ in. of distal palmar crease. Returned to work.
6	Burned middle finger, fusion of distal interphalangeal joint with healed fracture of middle phalanx due to osteomyelitis.	Limited flexion, actively and passively, at proximal interphalangeal joint.	Capsulectomy of collateral ligaments. Tenotomy of interossei.	70 degrees of active motion at proximal interphalangeal joint.
7	Fractured metacarpals of middle and ring fingers. Laceration of extensor tendon, ring finger.	Limitation in flexion and extension of middle and ring fingers.	Capsulectomy of collateral ligaments, proximal interphalangeal joints. Tenotomy of interossei. Tendolysis of flexor tendons.	Improvement fair in both flexion and extension.

TABLE I (*continued*)

Case No.	Injury	Disability	Operative Procedures	Results
8	Crushing injury with fracture of proximal phalanx, index finger.	Lacked 2½ in. actively and 2 in. passively on flexing to distal palmar crease. Malunion with bowing.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Osteotomy of proximal phalanx.	Bowing corrected. Lacks 2⅛ in. actively and 1½ in. passively on flexing to distal palmar crease.
9	Fractured proximal phalanx, index finger. Crushing injury.	Much cicatrix in finger. 15 degrees of active and passive motion at proximal interphalangeal joint.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Division of volar plate. Tendolysis of flexor and extensor tendons.	No improvement in either flexion or extension.
10	Fractured proximal phalanx, ring finger. Laceration of flexor tendons, little finger.	No active or passive motion at proximal interphalangeal joint, ring finger. Articular margin displaced and malunited. Lacked on flexing to distal palmar crease: Ring: 2½ in. actively, 2½ in. passively; Little: 2½ in. actively, 1½ in. passively.	Capsulectomy of collateral ligaments of proximal interphalangeal joint of ring and little fingers. Osteotomy of proximal phalanx, ring finger. Tendolysis of flexor tendons, ring and little fingers.	35 degrees of motion at proximal interphalangeal joint, ring finger. Flexes to within 1⅜ in. actively. Little finger flexes to distal palmar crease.
11	Fracture of proximal phalanx of index finger crushed in press.	No active or passive flexion at proximal interphalangeal joint.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Tendolysis of extensor tendon.	45 degrees of motion in proximal interphalangeal joint.
12	Fracture of proximal phalanx, middle finger.	Malunion of proximal phalanx. Lacked 1½ in. actively and 1 in. passively on flexing to distal palmar crease.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Corrective osteotomy.	Flexes actively to within 1 in. of distal palmar crease. Malunion corrected.
13	Laceration of flexor tendons, middle finger. Not repaired.	Lacked 2⅜ in. on flexing actively and passively to distal palmar crease.	Capsulectomy of proximal and distal interphalangeal joints. Tendon graft.	Flexes actively to within 1 in. of distal palmar crease.
14	Laceration of flexor profundus and sublimis tendons, index finger. Not repaired.	Lacked 3½ in. actively and passively on flexing to distal palmar crease.	Capsulectomy of proximal and distal interphalangeal joints. Tendon graft, flexor profundus tendon.	Flexes actively to within 1 in. of distal palmar crease. 70 degrees of motion at proximal interphalangeal joint. 25 degrees of motion at distal interphalangeal joint.

TABLE I (*continued*)

Case No.	Injury	Disability	Operative Procedures	Results
15	Laceration of flexor profundus tendon, middle finger. Not repaired.	No active or passive motion at distal interphalangeal joint.	Capsulectomy of collateral ligaments, distal interphalangeal joint. Repair by advancement, flexor profundus tendon.	25 degrees of active and passive motion at distal interphalangeal joint.
16	Laceration of flexor tendons, middle finger. Repaired.	Lacked 3 in. actively and 1 in. passively on flexing to distal palmar crease. Lacked 1½ in. of complete extension.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Division of volar plate. Tendolysis of flexor tendons.	Lacks 1 in. on actively flexing to the distal palmar crease. No gain in extension.
17	Laceration of flexor tendons and median nerve at wrist.	Ischaemic contracture of hand. Stiff metacarpophalangeal and interphalangeal joints. Lacked 2⅜ in. actively and passively on flexing fingers to distal palmar crease.	Capsulectomy of proximal and distal interphalangeal joints. Capsulectomy of metacarpophalangeal joints. Tenotomy of interossei. Tendolysis of finger flexors. Thumb cleft widened. Tendon transfer for opposition.	Flexes to within 1 in. of distal palmar crease, actively and passively.
18	Laceration of ring and little fingers.	No active or passive flexion at distal interphalangeal joint, ring finger. Little finger held in flexion.	Capsulectomy of distal interphalangeal joint, ring finger. Volar capsulectomy and division of collateral ligaments, little finger. Tendolysis of finger flexors.	25 degrees of flexion actively, at distal interphalangeal joint, ring finger. Active and passive extension of little finger improved.
19	Laceration of flexor tendons of index and middle fingers. Repaired with tendon grafts.	Lacked 1½ in. actively and passively on flexing index and middle fingers to distal palmar crease.	Tendolysis of tendon grafts. Capsulectomy of collateral ligaments, proximal interphalangeal joints.	Flexes index and middle fingers to ¾ in. of distal palmar crease, actively and passively.
20	Lost right arm and mangled left hand and arm in coal-mine machine.	No functional use in left hand. Had to be fed and dressed. Fingers in rigid extension at metacarpophalangeal and interphalangeal joints.	Several operations: Thumb cleft widened by muscle-stripping and skin graft. Tendon graft to extensor of index finger. Capsulectomy of proximal interphalangeal joints. Capsulectomy of metacarpophalangeal joints.	Flexes fingers to within 1¾ in. of distal palmar crease. Feeds and dresses self.

TABLE I (*continued*)

Case No.	Injury	Disability	Operative Procedures	Results
			Tendolysis of common extensors. Tenotomy of interossei.	
21	Amputation of terminal phalanges of index, middle, and ring fingers.	Lacked 2⅝ in. on flexing to distal palmar crease.	Capsulectomy of proximal interphalangeal joints.	On active flexion to distal palmar crease lacks: Index: 2 in.; Middle: 1¾ in.; Ring: 1 in.
22	Crushing injury of hand with traumatic amputation of ring and little fingers in conveyor belt.	Flexed index finger actively and passively to within 1¾ in. of distal palmar crease. Flexed middle finger to within 2⅜ in. of distal palmar crease. Cramping in hand with use.	Capsulectomy of proximal interphalangeal joints of index and middle fingers. Tenotomy of interossei.	Middle finger flexes to within 1 in. of distal palmar crease. Index finger touches palm. No cramping in hand with use.
23	Corn-picker injury. Amputation of middle and terminal phalanges of index, middle, and ring fingers.	Limited flexion at proximal interphalangeal joint of little finger, due to tight collateral ligaments and adhesions of flexor tendons.	Capsulectomy of collateral ligaments, proximal interphalangeal joint, little finger. Tendolysis of flexor tendons.	Improved.
24	Fractures of metacarpals of middle and ring fingers as a result of hand being caught in power mower.	Had only 15 degrees of active and passive flexion at proximal interphalangeal joint of middle finger. Ring finger not stiff in interphalangeal joint.	Capsulectomy of collateral ligaments, proximal interphalangeal joint. Tenotomy of interossei. Tendolysis of extensor tendon.	Has 95 degrees of active motion at proximal interphalangeal joint, middle finger.
25	Burn, forearm and hand.	Flexed fingers to within 1½ in. of distal palmar crease.	Capsulectomy of collateral ligaments of interphalangeal joints of all fingers and of distal interphalangeal joint of little finger.	Flexes all fingers to distal palmar crease.

OPERATIVE TECHNIQUE AND POSTOPERATIVE TREATMENT

The interphalangeal joint is approached by a lateral incision (Fig. 4-A). This incision is deepened through skin and subcutaneous tissue to expose a layer of deep fascia which has been previously described by Kaplan as extending volarly from the extensor-tendon mechanism on the dorsum to the sheath of the flexor tendon. Bunnell has described it as a "fascial sheet". This deep fascial cuff is preserved in order that stability in the joint can be maintained after the collateral ligaments have been excised. The collateral ligament to the proximal interphalangeal joint is best demonstrated by approaching the joint from the base of the middle phalanx and elevating the deep fascial

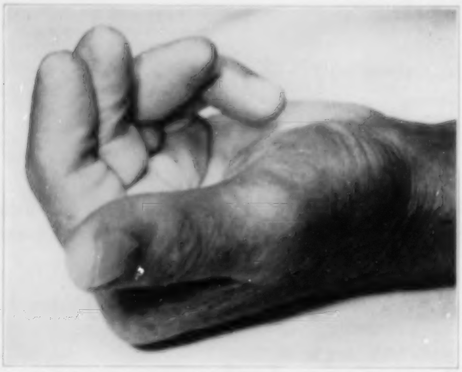

FIG. 7-A

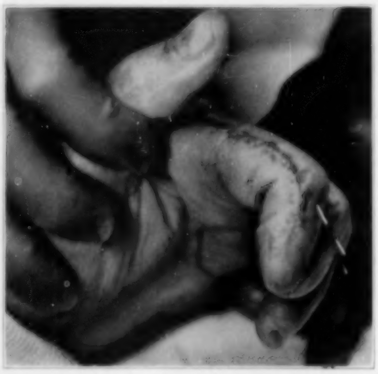

FIG. 7-B

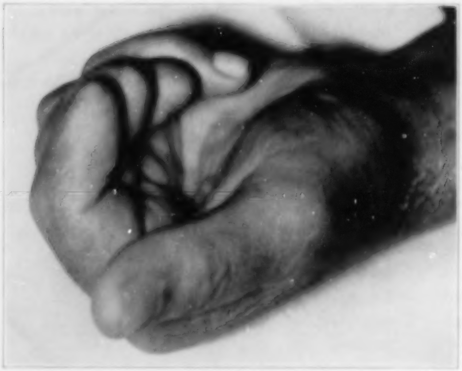

FIG. 7-C

Fig. 7-A: Case 21. Shows index, middle, ring, and little fingers after amputation of the terminal phalanges through the distal interphalangeal joint, and limitation of flexion at the proximal interphalangeal joint due to tight collateral ligaments. The patient is a farmer. He could not grip the steering wheel of a tractor.

Fig. 7-B: Shows fingers immediately postoperatively, with flexion gained at operation being maintained by fine Kirschner wires introduced into the distal end of the proximal phalanx.

Fig. 7-C: Flexion at proximal interphalangeal joint improved to such a point that the patient could drive tractor.

cuff (Fig. 4-A). A block of the ligament is excised on both sides of the joint, the surgeon attempting to remove as much of the ligament as possible, as shown in Figure 4-B.

When the distal interphalangeal joint is involved by the contracture, it is difficult to preserve a definite deep fascial cuff. However, no instability was encountered from a

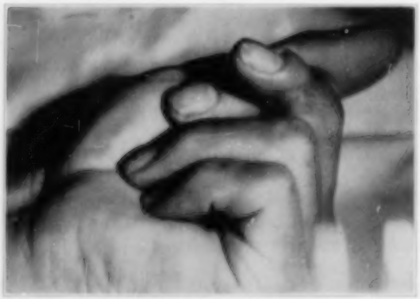

FIG. 8-A

Fig. 8-A: Case 6. Shows lack of flexion at proximal interphalangeal joint of the middle finger due to tight collateral ligaments and contracted interossei following burn, with osteomyelitis of the middle phalanx and destruction of the distal interphalangeal joint.

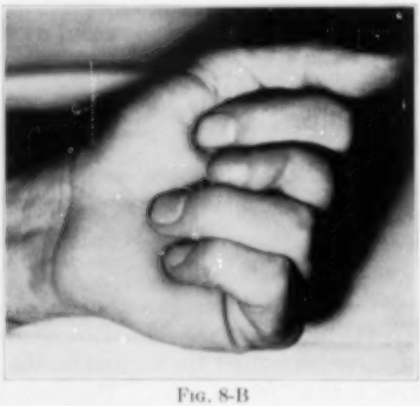

FIG. 8-B

Fig. 8-B: Postoperative photograph shows improved flexion at the proximal interphalangeal joint following capsulectomy of the collateral ligaments and tenotomy of the interossei.

simple division of the collateral ligaments or the volar plate. A lateral surgical approach was always used, and in some cases a block of the ligament could be excised instead of a simple division of the ligament being made.

In some cases, in which the condition is of long standing, the volar synovial pouch has become obliterated, and this must be re-formed with a small curved elevator or by forcing the base of the phalanx into flexion.

In those cases in which there is an associated contracture of the interosseus muscle, the interosseus tendon is lengthened by tenotomy and is then resutured; if necessary, the extensor-tendon mechanism can be freed over the dorsum of the finger by this operative approach.

Before closure of the wound, 0.5 cubic centimeter of hydrocortisone acetate is injected into each interphalangeal joint, as suggested by Howard, Bunnell, and Pratt. In order to maintain the fingers in a partially flexed position at the interphalangeal joint, a fine Kirschner wire is introduced into the distal end of the proximal phalanx with the middle phalanx in flexion (Fig. 7-B). This prevents one from losing the flexion gained at operation during the period of postoperative swelling. In five to seven days, the Kirschner wire is removed and rubber-band splinting is started. Figure 5-B illustrates the type of splint found to be most satisfactory. This splint gradually pulls the interphalangeal joints into acute flexion and at the same time produces extension at the metacarpophalangeal joints, thus stretching the contracted interosseus muscles, if these are associated in the contracture.

Splinting is continued until the patient is able to maintain by active and passive exercise the range of motion obtained postoperatively. In some cases, this has necessitated part-time splinting for as long as three or four months. In other instances, it has been necessary to alternate the splinting, so that the fingers are stretched into flexion one day and into extension the next day. Physical therapy, with active motion and careful passive motion, is begun as soon as wound healing will permit. By using paraffin baths, we have found that this can be started as early as five to seven days postoperatively.

The same operative approach is used in those cases which show limited extension. One can divide the volar plate of the capsular ligament with ease through this lateral operative approach. It has been found that in some joints, in which the capsule is primarily responsible for the contracture, it is also necessary to divide the collateral ligaments before extension can be obtained for, when the joint is held in acute flexion, the collateral ligaments become adherent to all the surrounding structures and so limit extension. When indicated, a tendolysis of the flexor tendons can be performed, as well as a division of the contracted sheath of the flexor tendon. Rubber-band splinting is begun immediately postoperatively, if possible, when the problem is one of limitation of extension, by the use of a cast with outrigger and rubber bands, or the Bunnell knuckle-bender splint with outrigger and rubber bands.

DISCUSSION OF CASES

This presentation is based on an analysis of fifty patients in whom there was persistent limitation of extension or flexion of the interphalangeal joints, despite conservative treatment consisting in special non-rigid splinting and physical and occupational therapy.

Limitation of Extension

The etiological factor which predisposed to this lack of function is interesting. In seven of the twenty-five patients, the lack of extension occurred secondary to the development of Dupuytren's contracture. It was found that surgical excision of the thickened fascia within the finger and a release of the contracted skin would not allow extension of the finger at the proximal interphalangeal joint. This extension, however, was obtained after division of the volar plate and collateral ligaments of the capsule of the joint; in some instances, it was necessary to divide the flexor tendon sheath, as well as to lengthen the flexor tendon.

In ten of the patients a flexion contracture or limited extension of the fingers had developed secondary to the primary repair of lacerated flexor tendons. At the time of the tendolysis of the flexor tendon within the finger, it had been necessary to divide the volar plate and the collateral ligaments of the capsule in order to obtain extension. In five of these patients, the sheath of the flexor tendon had also contracted and was divided.

The flexion contracture followed prolonged immobilization of the fingers in flexion for fractures of the proximal phalanges in two patients and a dislocation of the proximal interphalangeal joint in another.

In two patients, the limited extension followed burns to the fingers. At operation, release of the scar contracture of the skin did not allow passive extension; this was obtained only after a division of the volar plate and the collateral ligaments.

One patient with severe flexion contracture following arthritis of the hand showed considerable improvement following division of flexor-tendon sheath, volar plate, and collateral ligaments of both proximal and distal interphalangeal joints. In another patient, the lack of extension followed prolonged immobilization for Colles' fracture. In the last patient in this group, the deformity followed an old ulnar-nerve paralysis, and tendon transplantations were successful only after passive extension of the fingers had been obtained by a volar capsulectomy of the proximal interphalangeal joints. In this group of twenty-five patients, an improvement in range of motion and function was obtained in all, with no instability of the joints.

Limitation of Flexion

The most common cause for the limitation of flexion in the twenty-five patients studied was fracture of the fingers, particularly fracture of the proximal phalanx, which had been immobilized in the position of extension until healing occurred. There were twelve cases in this group. In one of these patients, in addition to tight collateral ligaments, there was a bony block from an exostosis. There were eight patients who had had tendon injury which required secondary tendolysis or tendon graft. Capsulectomy was performed at the time of the tendon-grafting in two patients, because intensive preoperative physical therapy and splinting had failed to produce good passive flexion of the interphalangeal joints; it was felt that, in order to achieve a good result postoperatively, one had to achieve good passive flexion of the finger at operation. A satisfactory result was obtained in these latter two patients.

The remaining patients had as the primary causes the following conditions: traumatic amputation of the terminal phalanges, severe crushing injuries to the hand and fingers, and burn of the hand and forearm.

In this group of patients in whom there was limitation of flexion, the procedures most commonly employed together were tenotomy of the interosseus tendons and capsulectomy of the interphalangeal joints. All patients had had prolonged periods of conservative treatment with non-rigid splinting and physical therapy. There was not one case of instability of the interphalangeal joints in this group, and improvement in function postoperatively was obtained in all but one patient.

Before one undertakes to carry out the procedure of capsulectomy to the interphalangeal joints to improve flexion, one would like to know what to expect as an end result and in what cases the procedure should be attempted. After reviewing the results in this series, it is apparent that, when one is dealing with limitation of flexion of the finger, and on examination the patient is able to flex to within one inch of the distal palmar crease, it is better judgment to rely on conservative measures to improve flexion. On the other hand, it is in the group of patients who have a lesser degree of flexion, even in those whose fingers are held in rigid extension, but without bony ankylosis, that one can expect to improve flexion by this operative procedure. This was true in this series, even though the procedure of capsulectomy had to be combined with other operative procedures when other anatomical structures were also limiting flexion.

The surgeon may wonder, too, whether flexion will be improved at the expense of extension. This may occur, particularly if active and passive extension are not encouraged early, in addition to active and passive flexion. However, this has been a complication only when we were dealing with badly scarred fingers which were held in rigid extension with little or no flexion at the interphalangeal joints. Postoperatively, several of these patients were unable to extend to a straight line. However, from a standpoint of hand function, they were much improved in that the fingers could be flexed for grasp, with some limited extension.

The results seem to indicate that the more anatomical structures are involved in the limitation of motion, the poorer is the end result. If the only limiting factor for flexion in the interphalangeal joint was a capsular ligament, then capsulectomy of the collateral ligaments gave a good result, both for flexion and extension. On the other hand, if it was necessary to free the extensor tendon over the proximal phalanx and to perform a tenotomy of the interossei and a capsulectomy of the collateral ligaments, in order to obtain flexion of the proximal interphalangeal joint, then the end result achieved by surgery was not so good. This was particularly true of the finger bound by cicatrix.

Thus, if one assesses the finger carefully before operation, he can determine with some degree of surety what the end result will be. In some patients, the increase in motion of only 20 to 30 degrees in the proximal interphalangeal joint gave a hand which could be used for work. This cannot be considered an unimportant gain for such an undertaking, since it made the difference between employment and no employment.

One should not expect to restore function completely by this procedure, but one can expect to improve it.

SUMMARY

A group of fifty patients, twenty-five of whom presented a limitation of extension of the fingers, and twenty-five a limitation of flexion of fingers, as a result of mechanical limitation at the interphalangeal joints, has been studied. In these patients, there were seventy-two interphalangeal joints subjected to surgery, in order to improve function after conservative measures had failed.

An operative procedure in which a lateral approach is used allows the operator to excise a portion of the collateral ligament from each side of the joint without disturbing the stability in the proximal interphalangeal joint. At the same time it provides easy access to all other structures which may play a role in blocking extension or flexion of the fingers at the interphalangeal joints.

The results in this series of patients lead to the conclusion that, when the interphalangeal joint is intrinsically in good condition as shown by the roentgenogram, one can expect a measurable improvement by the procedure of capsulectomy of the interphalangeal joints.

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DISCUSSION

Dr. E. B. Kaplan, New York, N. Y.: The essayist must be highly praised for this excellent presentation and for the results which he obtained from the application of his method. The accurate knowledge of the finer points of anatomy, skillful selection of cases, and proper technique in the execution of the surgical procedure contributed to the restoration and improvement of function of the interphalangeal joints.

The discussor has had the opportunity to treat stiff interphalangeal joints by removal of the head of the phalanx constituting the proximal segment of the distal or proximal interphalangeal joint or by capsulectomy. The problem of improving function of these joints is a difficult one, especially when there is instability following intervention. However, instability can be avoided if careful consideration is given to the structure of the dorsal apparatus and the flexor tunnel of a finger.

In the surgical procedure, after an appropriate incision of the skin has been decided upon, the dorsal extensor apparatus must be adequately exposed and the joint approached in the following manner: An incision is made parallel to the lateral band unilaterally or bilaterally. The dorsal extensor apparatus can be gently retracted, and the corresponding joint can be treated. After the procedure on the joint, the dorsal apparatus is replaced, but the line of incision which was made parallel to the band is sutured or, occasionally, left alone. The skin is sutured in the accepted manner. Traction (preferably skeletal) is applied.

As the essayist has demonstrated, the application of his method, proper selection of cases, and adequate knowledge of structural detail will contribute to solution of treatment of this complicated problem.

Dr. Sterling Bunnell, San Francisco, California: I believe that this contribution by Dr. Curtis is an important paper. He offers a solution to a problem we have been up against. We have had so much trouble with these stiff middle joints of the fingers that finally we thought the best treatment for them was occupational therapy and hard work. Occasionally, we have operated, doing capsulectomies, and we have made some gain, but we have not used quite the method shown by Dr. Curtis. We did not follow the operation with six weeks of traction, as we have learned to do for the proximal joints.

In flexor contraction of any joint, there is always one primary cause of contraction, and every tissue from skin to joint or bone is secondarily involved. This is especially true of these middle joints of the fingers.

A finger that has been in sharp flexion for a long time will not extend until both the capsular ligaments have been excised and the volar ligament has been cut across. If too much is cut, the joint will dislocate. Similarly, if the finger is out straight, the capsular ligaments will hold the joint either straight or flexed according to the position of the joint when they shorten.

Dr. Curtis brought out the point that the aponeurosis must be preserved for lateral stability. He retracts it proximally in order to excise the collateral ligaments and then leaves it as a sleeve for lateral stability. This step may be something well worth while.

DISCUSSION

Arthrodesis of the Hip in Wide Abduction

(Continued from page 1189)

Dr. Abbott (closing): I would like to emphasize that the shortening which takes place after this method of arthrodesis is insignificant. I must add that another difficulty which I have encountered with osteotomy is that the motion remaining is crippling because of pain, especially in patients who have to stand all day.

I still believe that the position of fusion is a matter of individual opinion. Some surgeons, for example, my associate, Dr. Frederic Bost, prefer a position of slight adduction. He feels that the patient has a better gait.

I would like to thank Dr. Key for his kindly remarks. I know that we were working together, but actually I did the first operation for arthrodesis in abduction at the Shriners' Hospital for Crippled Children in St. Louis. Dr. Key and I had many pleasant arguments about the conditions which produced the rapid and certain fusion.

POPLITEAL CYSTS ASSOCIATED WITH UNDIAGNOSED POSTERIOR LESIONS OF THE MEDIAL MENISCUS*

BY HAROLD M. CHILDRESS, M.D., JAMESTOWN, NEW YORK

This paper is particularly concerned with popliteal cysts, or bursae, accompanied by knee-joint effusion, but without pathological conditions of the bones or joint demonstrable by roentgenograms. Although nearly all popliteal cysts communicate with the joint, it is generally agreed that results following surgical excision are uniformly good, if recurrence can be prevented. Agreement is based on the assumption that the cyst, by intermittently discharging irritating fluid into the joint, produces a chronic synovitis.

That such optimism is unwarranted is concluded from a study of twenty-one consecutive excisions of the cyst during the past seven years. There have been no recurrences; yet the results were unsatisfactory in three patients. These patients had had previously undiagnosed posterior lacerations of the medial meniscus, as proved by subsequent arthrotomies. Each recovered completely following meniscectomy. The meniscal lesions cannot be detected by x-rays or by air injections into the joint; and, in the presence of a cyst, the clinical signs are obscured. In a careful review of the literature, no mention was found of the association of this condition of the meniscus, diagnosed or undiagnosed, with popliteal swelling.

Popliteal cysts—also known as Baker's cysts, popliteal bursitis, semimembranosus bursitis, and posterior synovial herniations—frequently communicate with the joint through a posterior capsular defect. Wilson, Eyre-Brook, and Francis found this opening to be present in seventeen of thirty dissected specimens from adults and in fifteen of twenty-two surgically excised cysts. In all of the fifteen cases reported by Meyerding and Van Demark there was communication with the joint. In this present series of twenty-one cysts, treated surgically, seventeen were found to have such an outlet. In practically every case, the communication was situated high up under the tendinous origin of the medial head of the gastrocnemius.

It has long been known that the popliteal cyst is often associated with an intra-articular pathological condition. In fact, the original investigators (Adams in 1840 and Baker in 1877) concluded that the swelling of the popliteal fossa was produced by osteo-arthritis at the knee. It is apparent that any condition which increases joint fluid may be the cause of a popliteal cyst. Suspected causes, therefore, in addition to many forms of arthritis, are severe trauma to regional soft tissues or to bone, osteochondritis dissecans, chondromalacia of the patella, Charcot's joint, and even arthrotomies. A reasonable explanation of the relationship is as follows: When excessive synovial fluid is developed within the joint, some of this fluid is forced through the posterior capsular opening into the semimembranosus bursa. This becomes distended, and its walls become inflamed, because of the multiple minimal trauma arising from ordinary motions at the knee. The popliteal swelling may persist, even though the original condition within the joint has subsided or has been corrected surgically. The action is now reversed and the bursa produces the fluid which is intermittently discharged into the joint. This cystic material is irritating to the synovial lining of the joint in which, in turn, an effusion is produced. On the other hand, direct or indirect trauma to the popliteal area may produce a primary reaction within a normal bursa. If it communicates with the joint, the latter may become secondarily involved in the manner described.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 24, 1954.

A problem confronts the examiner who finds a posterior cyst or bursa in a knee which has, or has had, an effusion. Is the cyst primary or secondary? Is it because *of*, or is it caused *by*, the synovial reaction? In the presence of negative roentgenograms and with neither the history nor the physical signs of a joint lesion, one concludes that the cyst is primary and that it should be surgically removed. This form of reasoning resulted in three complete failures in the author's group of patients, even though the cyst did not recur after surgery. Careful study of these three cases led to the conclusion that the cyst had been given too prominent a role in the patient's complaints. Signs of a meniscal lesion were indefinite or were concealed by the bulging cyst and the joint effusion.

CASE REPORTS

CASE 1. A heavily muscled automobile mechanic, thirty-four years old, had injured his left knee when he had slipped on an oily floor. Three months later a definite tumor had developed at the popliteal fossa, and the patient was unable to work. Examination revealed a definite popliteal cyst, associated with increased joint fluid. Quadriceps atrophy of one-half inch was present, and the patient walked with a limp. The cyst was excised and was found to be a distended semimembranosus bursa connected to the joint by a one-inch isthmus. Closure of the defect was done with silk mattress sutures. The cyst did not recur, but joint effusion persisted. Complaints became generalized at the knee, mostly at the medial aspect. Arthrotomy was done twelve months later, and the posterior medial meniscus was found to be oedematous and to have two old lacerations. Total meniscectomy was done. The patient's complaints diminished, and he returned to work in six weeks.

CASE 2. A machinist, sixty years old, had twisted his right knee while working. Swelling at the popliteal space had been noted four weeks later; this continued to increase in size. Examination showed quadriceps atrophy of one-half inch, marked joint effusion, and a large popliteal cyst medial to the mid-line. A definite fluid wave could be transmitted both from the joint to the cyst and from the cyst to the joint. Surgery disclosed the cyst to be a semimembranosus bursa with an oval capsular defect one and one-half inches long which allowed communication with the joint. A graft from the medial gastrocnemius tendon was used to close the opening. The cyst did not recur, but increased joint fluid persisted. The patient was able to work. Two months later, at arthrotomy, the posterior portion of the medial meniscus was found to be frayed and detached. Total meniscectomy was done. The patient made excellent progress and he returned to work in five weeks.

CASE 3. A carpenter, fifty-one years old, had injured his right knee while carrying a bag of cement. Two months later he had noticed popliteal swelling. Examination revealed quadriceps atrophy of one-half inch, moderate joint effusion, and a moderate-sized popliteal cyst. Moderate osteo-arthritic changes were seen in the roentgenograms. The distended bursa communicated with the joint by a one-inch opening. This was closed by silk mattress sutures. The cyst did not recur, but the patient continued to have complaints about his joint and persistent synovial reaction. Arthrotomy was performed four months later; the posterior two-fifths of the medial meniscus was frayed and degenerated, and there was chondromalacia of the patella. Total meniscectomy was done and the articular cartilage of the patella was removed. The patient's improvement was gradual, and he returned to work in seven weeks.

It is apparent that the joint lesion in these three patients was primary. Had it been diagnosed accurately and had it been treated early, many months of disability would have been avoided. In addition, had the original lesion been treated promptly, the cyst might not have appeared or might have disappeared spontaneously.

A new approach is being advocated for a patient with this type of condition. Both the joint and the cyst should be completely aspirated, and the knee should be carefully examined for internal derangement. The use of air injections into the cyst or the joint, in order to demonstrate a communication between the cyst and the joint, has been discontinued. It is believed that, if the surgeon is diligent in his search during surgery, he will certainly find the communication if such exists. An aid to this exploration is mentioned in the discussion of the surgical technique.

In a review of a group of proved isolated posterior lesions of the medial meniscus, it was found that the majority of such lesions occurred when the patient was in a crouched-down or squatting position. Consequently, a manoeuvre, termed the "duck-waddle" test, was devised. The test is based on complete knee flexion with the patient bearing weight; the patient squats down and waddles backward and forward, twisting from side to side. This is a common conditioning exercise for football players and is a definite aid in the diagnosis of a posterior lesion of the medial meniscus. Pain, with or without an accompanying intra-articular click, denotes a positive response.

In these patients, four signs have been found to be valuable in making a diagnosis:

1. Local tenderness on pressure and mild to moderate bulging at the medial or posteromedial joint line with the knee in hyperextension and bearing weight;
2. Pain on forced adduction of the extended knee—no pain on abduction;
3. McMurray's sign;
4. The "duck-waddle" test.

Three patients have been encountered in whom the diagnosis of popliteal cyst and a lesion of the posterior portion of the medial meniscus was made at the original examination.

CASE 4. A nurse, twenty-one years old, in whom a popliteal cyst developed, had had persistent discomfort in the left knee for about one year. Her primary concern was with the cyst and not with the joint. There was moderately increased joint fluid and quadriceps atrophy of one-half inch. The cyst contained thick yellowish fluid. Tests indicated a lesion of the posterior portion of the medial meniscus. An old laceration of the posterior portion of the medial meniscus was found at arthrotomy. The cyst disappeared four weeks postoperatively; there has been no recurrence in a period of five years.

CASE 5. A male factory worker, fifty-two years old, complained of pain in the right knee of several years' duration, with instability but no locking. Examination disclosed a small cyst medial to the mid-line, of which patient was not aware, quadriceps atrophy of one-half inch, and moderately increased joint fluid. The cyst contained gelatinous clear-colored material. Signs indicated a lesion of the posterior portion of the medial meniscus, this was found at arthrotomy. Pressure upon the popliteal area forced the cystic contents into the joint. No attempt was made to excise the cyst, and it was not possible to close the small communicating channel through the original incision. The cyst has not recurred in a period of three years.

CASE 6. A laborer, forty-three years old, had a popliteal swelling of two years' duration which developed shortly after he had twisted his right knee. Multiple aspirations were of no benefit; surgical excision of the cyst was done. Within two months the cyst recurred; it was again excised by his physician. After another recurrence, the patient refused further surgery. He had not been able to return to his regular work. When he was seen in consultation, examination showed quadriceps atrophy of one inch and markedly increased joint fluid, with a large cyst medial to the mid-line of the popliteal fossa. A thin yellowish fluid was aspirated from the cyst. Following complete aspiration of both the cyst and the joint, tests indicated a lesion of the posterior portion of the medial meniscus. The entire posterior horn of the medial meniscus was found to be frayed and hypertrophic. Although the patient had no complaints after meniscectomy, the cyst persisted. Two months later the cyst was excised, and it was found to communicate with the joint by means of a one-inch posterior capsular defect which had not been repaired previously. A tendon graft was used to close the defect. The cyst has not recurred in a period of two years; synovial reaction persisted for seven months.

The cyst in Case 5 may not have been a result of joint derangement. Had it been credited, however, with producing the patient's complaints, then certain failure would have resulted. Case 6 illustrates well why this study was made. Had the joint lesion been recognized at the original examination, the patient would probably have been spared three operations and over two years of partial disability. Furthermore, had the communication been found and adequately repaired at the first operation, the two recurrences would have been avoided. The importance of properly closing these openings cannot be stressed too emphatically.

The author has been unable to find any reported instances in which a popliteal cyst or distended bursa was considered secondary to a proved lesion of the posterior portion of the medial meniscus. Haggart stated that in his group of twenty-two true posterior synovial herniations, 60 per cent. presented signs which suggested internal derangement of the articulation. He inferred that the cyst produced these signs and that

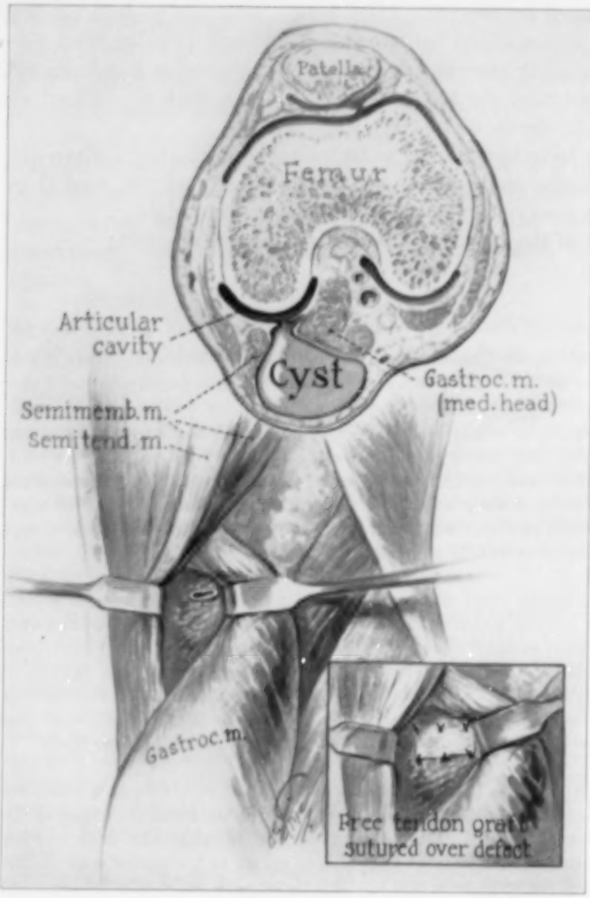

FIG. 1

Drawing illustrates communication of the cyst with the joint and the closing of the opening by means of a tendon graft.

they disappeared upon removal of the cyst. Burman reported on four patients with popliteal cysts and with lesions of the medial meniscus which had been produced by common trauma. Two meniscal lacerations were proved at arthrotomy. He emphasized that the two conditions were not related and that they should be regarded as two separate entities. Casagrande, however, recently treated a patient with an injury similar to those recorded in this paper. The patient had sustained an injury to the right knee several months previously. A few months later, a large popliteal cyst appeared which was excised by his physician. He continued to have joint complaints and at arthrotomy a typical parrot-beak tear of the posterior horn of the medial meniscus was found. Recovery was complete. Yancey also treated a patient with a typical lesion. His patient, a young professional baseball player, had injured his right knee two years previously; injury was followed a few months later by a cyst at the medial popliteal space. The cyst was present only at intervals. At arthrotomy, in November 1953, a posterior lesion of the medial meniscus was found. The popliteal cyst reappeared soon after the operation, and excision was necessary three months later. He recovered completely.

SURGICAL TECHNIQUE

With the patient lying prone and the knee flexed about 25 degrees, a curved longitudinal incision is made convex medially. No tourniquet is required if the cyst is a distended semimembranosus bursa, as little bleeding is encountered in these fascial and muscle planes. Despite textbook descriptions to the contrary, a definite pedicle or stalk is rarely encountered. Usually the base covers an area of the posterior joint capsule, one inch or more in diameter. If a communication exists, it is nearly always under the tendinous insertion of the medial head of the gastrocnemius muscle (Fig. 1). Strong retraction up, and lateral to, the tendon is essential. If the search is unsuccessful a small amount of saline solution tinted with methylene blue may be injected into the joint through the posterior portion of the capsule. Air, rather than fluid, may be used. This will cause a bulging-out of the pouch; then, upon retraction of the medial gastrocnemius, the opening may be defined by the dye solution or by bubbles. If the aperture is small, its edges, after scarification, may be plicated or approximated snugly by silk or cotton sutures. If the opening is large, a free tendon graft is used (Fig. 1), as originally described by Haggart. The exposed semimembranosus or medial gastrocnemius tendon provides sufficient material. Before closure, it is important that the surgeon test the suture line by bringing the knee into full extension and re examining the site of repair. Sponge-rubber pressure pads are placed over the popliteal fossa and the suprapatellar pouch before a plaster knee cylinder is applied with the knee in extension of 180 degrees.

In order that misinterpretation of this study may be avoided, further factors must be considered. One would certainly not expect to find posterior meniscal lesions in six of twenty-one patients with popliteal cysts; this, however, is the number of patients who were subjected to meniscectomy. Thirty-five additional patients were seen during this period; these were not subjected to surgery. The six lesions of the medial meniscus occurred, therefore, in a total of fifty-six patients with popliteal cysts—an incidence of about one in ten. Since the majority of these were referred patients, many had received previous treatment and most had accompanying joint complaints. In such a group one would undoubtedly encounter a greater than average number of related articular conditions.

CONCLUSIONS

1. The usual popliteal cyst is a distended semimembranosus bursa, frequently communicating with the joint through a posterior defect which is rather constant in location.

2. Successful excision of the cyst without recurrence does not ensure a successful result in all patients. The cyst may be secondary to an obscure or concealed joint lesion.

3. A lesion of the posterior portion of the medial meniscus should be suspected, even though it is not evident in the roentgenograms, when the cyst has, or has had, an associated joint effusion of unknown etiology.

4. Early diagnosis and surgical treatment of the meniscal lesion will prevent the formation of such cysts.

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DISCUSSION

Dr. William H. Bickel, Rochester, Minnesota: Anatomically, it is a known fact that several of the bursae about the knee communicate with the knee joint. The popliteal bursa, the semimembranosus bursa, and the bursa beneath the head of the gastrocnemius muscle most frequently communicate with the knee joint. The communication may be small or it may be large, and it is usually beneath either the origin or the insertion of the muscles. When the knee is extended, the openings are closed; when the knee is flexed, the mouths of the bursae are open. The fluid can communicate with the bursa in the posterior aspect of the knee joint better with the knee in a flexed position. Perhaps the butterfly valve action of these muscles,

(Continued on page 1240)

ARTERIAL VASCULARIZATION OF THE SOFT TISSUES OF THE HAND *†

BY HERBERT CONWAY, M.D., AND RICHARD B. STARK, M.D., NEW YORK, N. Y.

From the Department of Surgery (Plastic), The New York Hospital-Cornell Medical Center, New York

A slough of the soft tissues or a delay in the healing of wounds in the central part of the palm occurs sufficiently often following surgical intervention to warrant investigation of the degree of vascularity of this area.

The subject of surface vascularization has been relatively neglected since the latter part of the nineteenth century, when Manchot published his classic monograph. His work was the result of dissections on cadavera, as is the work to be presented in this paper.

TECHNIQUE

In both upper extremities of five cadavera from the dissecting room, radiopaque fluid (thorium dioxide) was injected into the radial and ulnar arteries. Arteriograms were made of the vascular tree of the skin and subcutaneous tissue of the palm after these soft tissues had been dissected cleanly from the deep fascia, palmar aponeurosis, and tendon sheaths.

RESULTS

The arterial vascularization of the skin and subcutaneous tissue of the volar aspect of the hand takes place by means of arterioles and capillaries which run perpendicular to the surface of the skin. Most of these are endarterial tufts and only in the area of the digits did we find the longitudinal circulation which courses parallel to the surface of the skin in the digital arteries. Three distinct zones of abundant vascularity were found. The thenar and hypothenar areas and the soft tissues of the palm distal to the distal flexion crease presented areas of abundant circulation. However, a triangular zone bordered by these three areas showed a paucity of arterial circulation. This triangle rests in the central portion of the palm, its apex being proximal. This has been a constant finding in all ten of the palms which were studied.

DISCUSSION

In the operation of fasciectomy for Dupuytren's contracture, it is necessary to undermine flaps of skin and subcutaneous tissue widely, both proximally and distally, if the palmar aponeurosis is to be excised completely. However, such wide undermining of the soft tissues of the palm in the triangular region of limited vascularity leads not infrequently to slough of one or both of the flaps, or to delayed wound healing. If ideal wound healing is to be obtained, undermining of these flaps necessarily must be limited. This presupposes a limited excision of the palmar fascia, which can be accomplished through a short, curvilinear Meyerding-Bunnell incision. Through this, only the palmar aponeurosis to the long, ring, and little fingers can be exposed with ease; however, involvement of the palmar fascia leading to the index finger occurs infrequently. It was involved in only 11 per cent. of the eighty-eight cases of Dupuytren's contracture treated at The New York Hospital.

The alternative to the limited undermining of the skin and subcutaneous tissues and

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* Presented at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 22, 1954.

† This work was aided by United States Public Health Service Grant No. H-466.

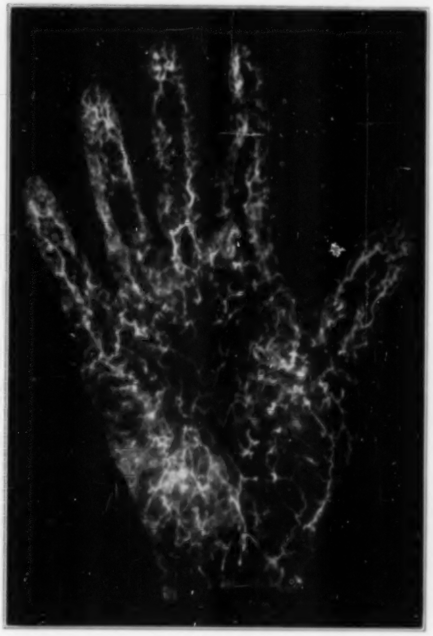

Fig. 1

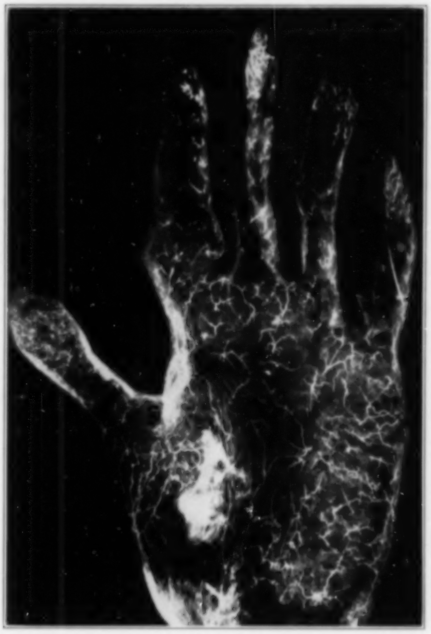

Fig. 2

Figs. 1 to 3: A triangular zone of limited arterial vascularity is present in the central portion of the palm, with its apex proximal. This triangular zone is surrounded by three zones of marked vascularization, — namely, the thenar area, the hypothenar area, and the palmar area distal to the flexion crease. This triangular area of limited palmar vascularity was found to be constant in ten cadavera. It is believed to be the underlying cause of the complication of delayed wound healing or palmar slough following fasciectomy for Dupuytren's contracture. (Fig. 1 reproduced by permission of The Williams and Wilkins Co. from *Plastic and Reconstructive Surgery*, **12**: 358, 1953, and from *Revista Latino Americana de Cirugia Plastica*, **1**: 34, 1953.)

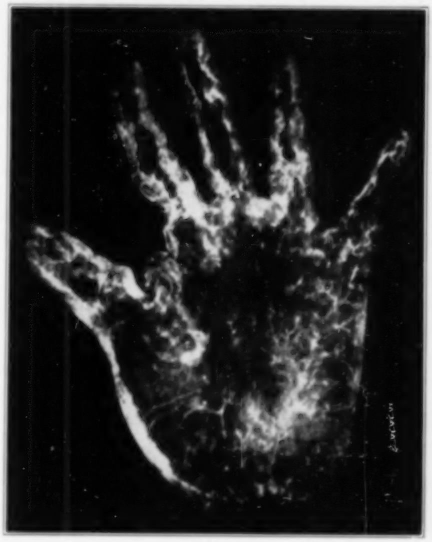

Fig. 3

the limited excision of the palmar aponeurosis is the complete removal of the palmar aponeurosis. When flaps are of questionable viability, those portions which show circulatory embarrassment must be excised and the palmar defects must then be covered by pedicled flaps.

Whether the zone of anatomical weakness, turned back as a flap, should be replaced by a skin graft, as Lexer did many years ago, is a matter for surgical judgment. A graft of the palm is superior certainly to palmar necrosis or delayed wound healing. In any case, the operation for Dupuytren's contracture is one which should not be trusted to the surgeon in training without supervision.

SUMMARY AND CONCLUSIONS

The central area of the palm contains a triangular zone which is poorly vascularized. Because of the paucity of blood vessels, extensive undermining of this flap may invite delayed wound healing or frank necrosis. Appreciation of this important anatomical weakness has led the authors to adopt the principles of limited undermining of the skin and subcutaneous tissue of the palm or, following undermining of an extensive degree, the primary excision of non-viable marginal tissue and coverage by skin grafts or pedicled flaps.

NOTE: The thorium dioxide in the form of Thorotrast and Umbrathor was supplied through the courtesy of the Heyden Chemical Corporation, New York, N. Y.

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DISCUSSION

POPLITEAL CYSTS

(Continued from page 1237)

when the knee is extended, helps to entrap some of this fluid within the bursa; however, the fluid within the bursa is not characteristic of joint fluid. Perhaps it is altered by stagnation or by some local process within the bursa itself.

I would like to ask the author how many cases of synovitis of the knee joint he has seen in which he has felt that the synovitis was secondary to disease within the bursa. The intra-articular lesion is present in a significant number of cases of popliteal cyst. Joint effusion usually is present in these cases. In fourteen of one hundred consecutive cases in which a popliteal cyst was removed at the Mayo Clinic, rheumatoid arthritis was present, and the cyst was felt to be secondary to the rheumatoid arthritis or perhaps due to similar synovial change within the bursa itself. In an additional 12 per cent. of the cases, the patients had intra-articular disease of one form or another. The cyst was associated with a tear in the meniscus in only two patients. In one of these cases, the meniscectomy was done at the same time the bursa was removed; in the other, it was done four months later. Perhaps we are missing the diagnosis preoperatively or are not recognizing the fact that the patient is not cured after the removal of these cysts. Dr. Childress has put us on our mettle. His Cases 1, 2, and 3 are very convincing. One should remember what Dr. Childress has said. I have enjoyed hearing his presentation and the pertinent observations he has made. I have a personal interest in his remarks because the result of a "duck-waddle" test on my left knee has been positive. I shall diligently watch for the development of my popliteal cyst.

DR. CHILDRESS (closing): I wish to thank Dr. Bickel for his remarks. In answer to his question concerning a joint reaction secondary to the cyst I would say that such would be most unusual. My contention is that the primary lesion is usually within the knee when the cyst is associated with a joint effusion. Watson-Jones[a] states that a lesion of the posterior medial meniscus is often overlooked. Since one often finds that for which he searches, I will wager that there will be more than two instances of meniscal injuries in the next hundred popliteal cysts excised at the Mayo Clinic.

In describing the "duck-waddle" test, one might say that it is a weight-bearing McMurray sign. It is a common conditioning exercise for football players and is rather strenuous. One squats down and then waddles back and forth and twists from side to side. If this can be done without pain or marked clicking at the joint, I will guarantee that the posterior portion of the medial meniscus is normal. The diagnosis of this lesion is not made by one test but is a matter of judgment. Four signs have been listed which I feel certain are reliable in pointing out this condition.

[a] WATSON-JONES, REGINALD: Fractures and Joint Injuries. Ed. 3, p. 714. Baltimore, The Williams and Wilkins Company, 1946.

ECHINOCOCCUS DISEASE OF BONE

Report of a Case

BY MAJOR DAVID C. KELLSEY, *Medical Corps, United States Air Force,*
AND MAJOR HARRY F. SPROAT, *Medical Corps, United States Army*

From the Orthopaedic Service, Brooke Army Hospital, Fort Sam Houston, Texas

Although the reported incidence of bone infection with *Taenia echinococcus* is only 0.5 to 1.5 per cent.[1,2,4,9,10,15], there are many individual case reports in the English-language literature and a few reviews of the clinical course of the disease. The authors are reporting a case observed in Brooke Army Hospital, Fort Sam Houston, Texas, between December 1952 and April 1953. During our perusal of the available literature we have failed to find any reports which included as complete a pathological study as this present report*.

Experience with echinococcus disease of bone in the United States has been extremely limited, because up to the present time only ten cases have been reported which were studied on the North American continent[4,7,8,9,11,16,17,18,19]. The largest series of collected cases of echinococcosis (irrespective of organs or tissues involved) studied on this continent totals 482[12]. Only twenty-three of these cases apparently occurred in native-born—the rest, more than 95 per cent., occurred in immigrants. The present patient, although studied in the United States, apparently acquired the disease in Puerto Rico.

PATHOLOGY

Man, although a relatively uncommon intermediary host, may be infected by the ova-containing excreta of dogs. This is more particularly seen in the great sheep-raising areas of the world.

Within approximately three weeks from the time the embryos reach their definitive organ or tissue in the intermediary host, they develop into the larval or cystic form. The cyst consists of two coats, an external laminated layer and an internal nucleated germinal layer. The external laminated layer is surrounded by an adventitia thrown up by the host.

Because of the architecture of osseous tissue, microcysts occur rather than the single large cysts which are commonly seen in the liver[2]. No regular adventitia is seen, but in places a pseudo-tubercular reaction may be noted. The hydatids infiltrate, destroy, and replace the bone they infest. Finally the cortex gives way, and extra-osseous signs of hydatid infestation become apparent.

SKELETAL DISTRIBUTION

The initial bone lesion may remain localized or extend to an entire bone. Ordinarily bones are first involved by arterial spread after the embryos have cleared the first two filters—the liver and the lungs. Howorth, basing his figures on the larger series in the literature, reported that the pelvis was involved in about 36 per cent., the spine in 18 per cent., the femur in 17 per cent., the sacrum in 11 per cent., the humerus in 10 per cent., and the tibia in 9 per cent.

ROENTGENOGRAPHIC CHARACTERISTICS

There is an absence of both clinical and roentgenographic signs of hydatid infections of bone for a long period of time[2]. The first stage of bone involvement[2] consists in an invasion of the relatively well vascularized area of the epiphysis. The hydatid cysts then spread along lines of least resistance. Examination of the roentgenograms at this stage may reveal multiple minute, rounded, cystlike spaces limited by thin trabeculae. Early in the disease little periosteal bone develops and there is very little cortical expansion. However, as a result of prolonged and clinically almost silent irritation, hyperostosis usually predominates over osteolysis[2,14,15]. Thus, later in the course of the disease, a second stage of bone involvement is noted. Enclosed cystic areas within the development of a surrounding inflammatory osteitis appear. There is never any sharp demarcation between the normal and the diseased areas; this is a helpful fact to remember in making a differential diagnosis. As the disease advances, the cortex finally becomes thinned by increasing internal pressure and pathological fractures may occur.

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* Dr. Lent C. Johnson of the Armed Forces Institute of Pathology concurred both in this belief and in the pathological diagnosis of the case.

ROENTGENOGRAPHIC DIFFERENTIAL DIAGNOSIS

During the first stage of bone involvement, the disease may be mistaken for such rarefying bone lesions as osteosarcoma, giant-cell tumor, von Recklinghausen's disease (osteitis fibrosa cystica), vertebral angioma, or monostotic Paget's disease. During the second stage of bone involvement, the disease may be confused with osseous tuberculosis and with lues.

In osteogenic sarcoma the distinguishing feature is the presence of the "sun-ray" appearance about the periosteum. In giant-cell tumor there is a sharp boundary between normal and diseased bone. The multiple involvement prevalent in von Recklinghausen's disease, together with blood-chemistry studies, serve to differentiate this condition. There is a marked roentgenographic similarity between vertebral angioma and vertebral echinococcosis.

Monostotic Paget's disease may be differentiated if an increase in the serum phosphatase is found.

As the disease advances, progressive hyperostosis results and in its second stage the condition may thus become confused with tuberculosis or lues, but at this time clinical differentiation can be made. An adequate biopsy offers the best solution to the problem.

CLINICAL PICTURE

When bone is involved, a vaguely rheumatic picture may occur[12] which precedes by several years the rupture of the cysts through the cortex. Pathological fracture may be the presenting symptom.

Vertebral lesions may result in signs and symptoms of cord compression. Following rupture of the hydatid cyst through the cortex, the contiguous soft tissues become involved[13,20]. Secondarily, osteomyelitis commonly appears.

If it is decided to perform a biopsy of the lesion or to puncture a cyst, particularly one of extra-osseous nature, it should be remembered that peculiar anaphylactic manifestations may result. It is believed that these are due to the sudden absorption of specific protein in a sensitized patient. Dew listed the following systemic complications which have been observed singly and in combination after rupture or puncture of an echinococcus cyst: dyspnoea, cough, cyanosis, cardiac symptoms, agitation, pyrexia, urticaria, pruritus, vomiting, delirium, pulmonary oedema, and dilated pupils; occasionally, sudden death may occur.

LABORATORY DIAGNOSIS

The Casoni skin sensitivity reaction, in which treated cyst fluid is used as the antigen, is reliable and is reputedly positive in 95 per cent. of cases[9]. False positives may occur[12]. The complement-fixation test of Weinberg is slightly more complicated, but in doubtful cases it may help to establish or to support a diagnosis of echinococcus disease of bone. It is positive in approximately 90 per cent. of cases. Precipitin tests are available, but they are much less reliable. Eosinophilia is present in active hydatid disease, with levels of about 5 per cent. of the differential white-blood-cell count.

TREATMENT

It is reported[9] that excision proves to be the best treatment. However, there are attendant risks, such as anaphylaxis and possible further implantation of the hydatids. Amputation well above the site of the lesion has been practised. Local excision followed by packing the cavity with bone chips has been done in one case[9], with a good result. Capurro and Pedemonte substituted an entire femur from a fresh cadaver for one in their patient which was completely involved with hydatid disease. Another alternative might be the fashioning of a humerus of Vitallium to replace the one completely involved by echinococcus infestation. Although the authors have had no experience with so ambitious a prosthetic device, they feel the approach of Capurro and Pedemonte would be more satisfactory if it is desired to consider a procedure aimed at preserving the extremity.

There is no known specific treatment for the disease. That which is available is palliative or only locally effective rather than systemically effective. It was not felt at the time the authors' patient was originally undergoing study that any of the methods listed were particularly applicable. Shoulder disarticulation would have eradicated the local disease, but, as the patient was asymptomatic and had no interference with function, this method did not appeal to him or to us. The question of hidden involvement elsewhere in the body must be considered, for isolated bone involvement in a primarily systemic disease is rare[1,2,4,9,10,15]. Thus the problem is most complex and has not been satisfactorily settled.

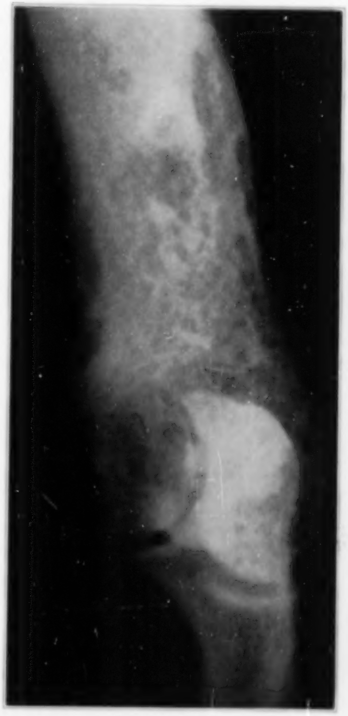

FIG. 1

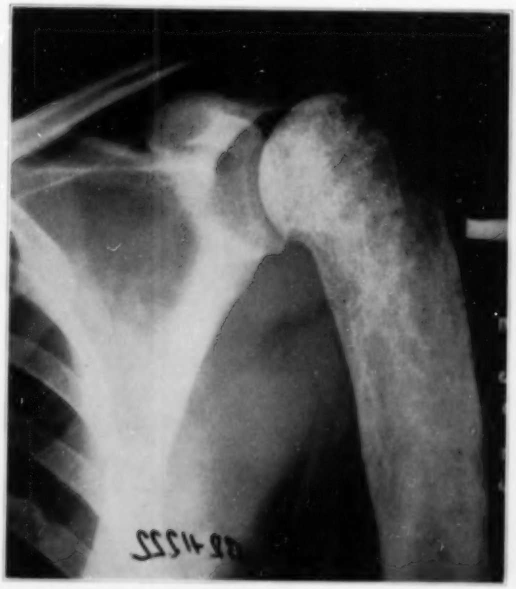

FIG. 2

Fig. 1: (Br. 11222–4.) Roentgenogram, made before operation, was enlarged to show the appearance of echinococcus disease in the distal end of the humerus.

Fig. 2: (Br. 11222–1.) Roentgenogram, made at Rodriguez Army Hospital early in June 1953, illustrating the degree of involvement.

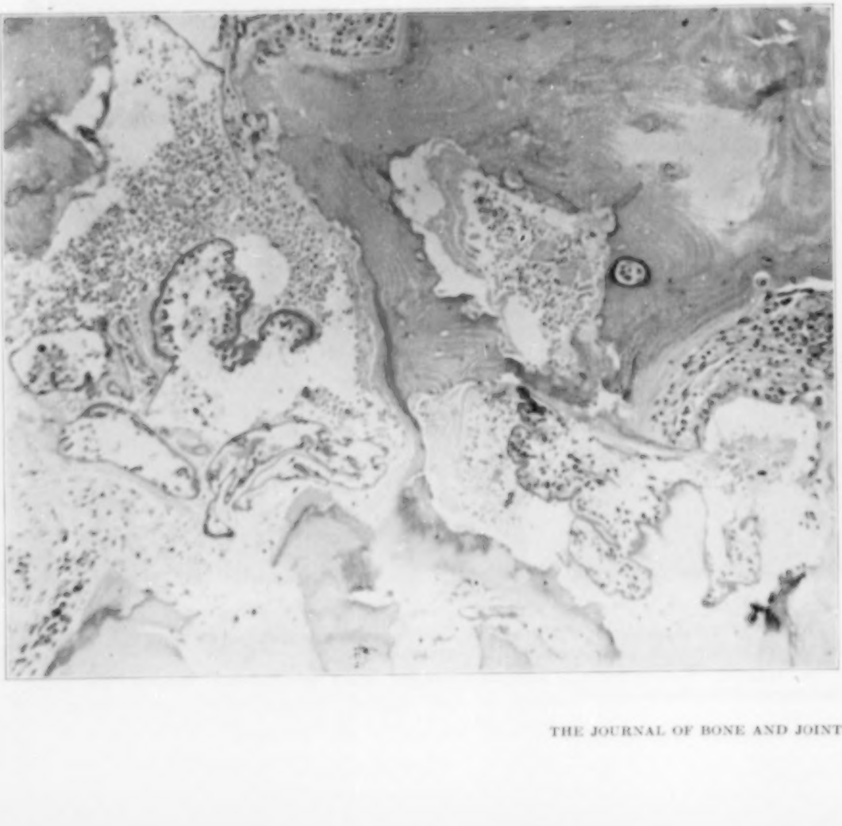

FIG. 3

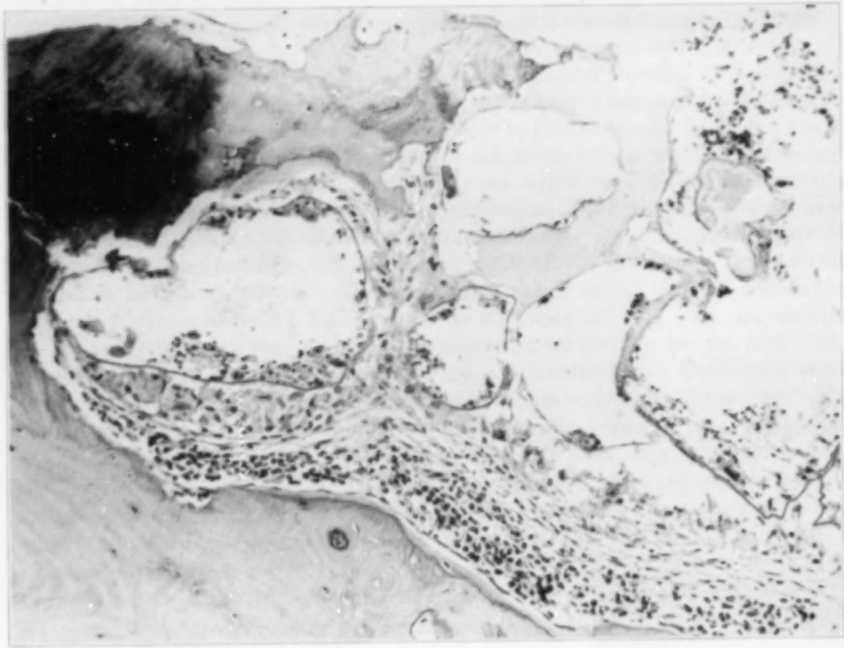

FIG. 4

Fig. 3: (Br. 11222-1.) The photomicrograph (× 100) showed multiple microcysts.

Fig. 4: (Br. 11222-4.) The photomicrograph (× 115) revealed the microcystic process, showing the surrounding epithelioid reaction and chronic inflammatory cell infiltrate.

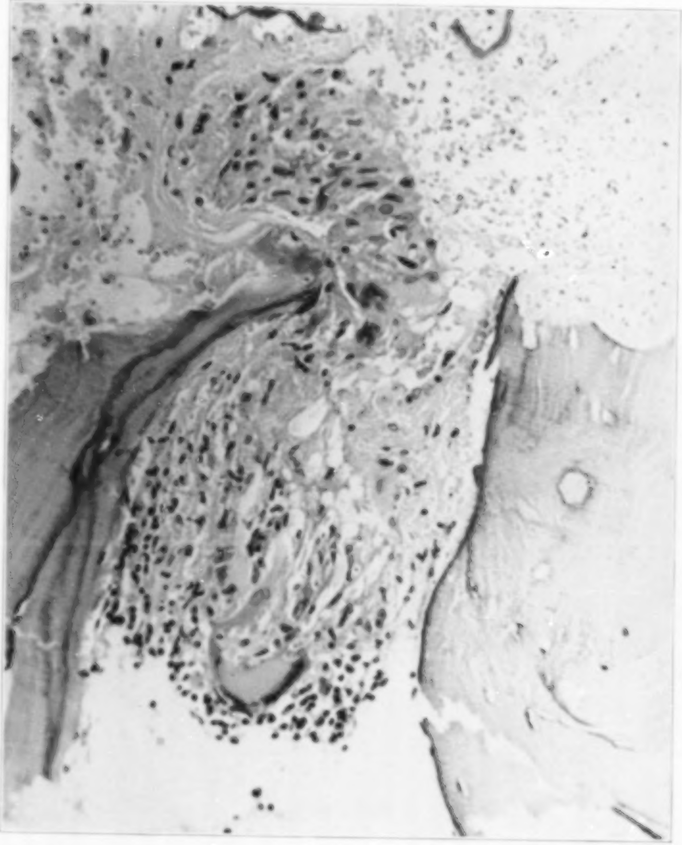

Fig. 5

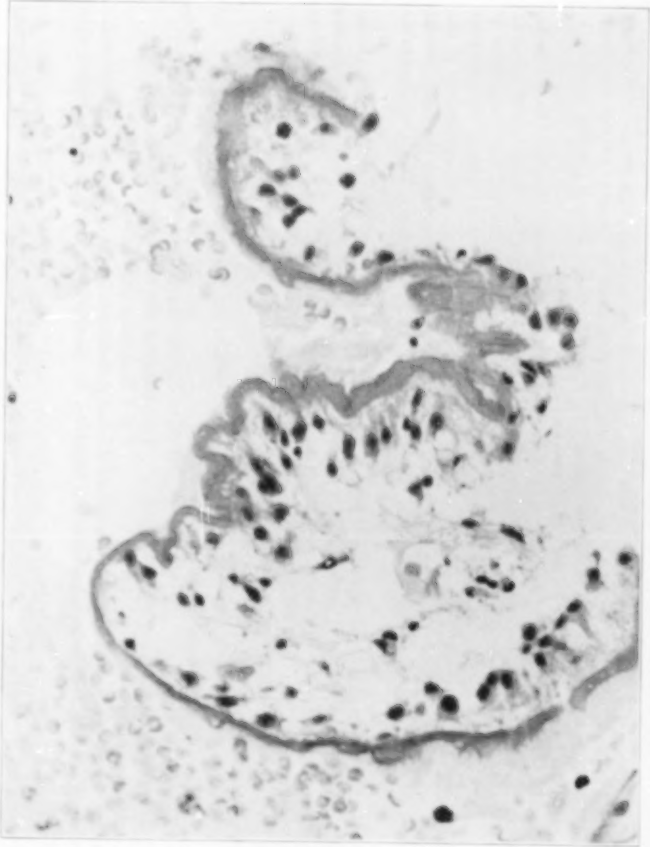

Fig. 6

Fig. 5: (Br. 11222-5.) Photomicrograph (× 190) demonstrating the granulomatous reaction.
Fig. 6: (Br. 11222-6.) Photomicrograph (× 445) of the cyst wall with internal germinating cell layer.

CASE REPORT WITH DISCUSSION OF PATHOLOGICAL FINDINGS

E. B., Brooke Army Hospital, No. 2922046, was a fifty-year-old Puerto Rican with twenty-three years of service in the regular Army. He had spent his youth working with sheep in the area around San Juan, Puerto Rico. His overseas service from his home territory of Puerto Rico had included a tour of duty in Panama in the 1920's and a brief tour of duty in France in 1952.

Present history: He had been initially hospitalized at the United States Army Hospital, La Rochelle, France, on November 10, 1952, because of complaints of a vague, generalized, dull aching pain and a feeling of diminished strength in the left arm and elbow of three weeks' duration. He also had had complaints of mild exertional dyspnoea for two months prior to hospitalization. He had no other complaints. Because of right bundle-branch block, mild decompensation, and a peculiar roentgenographic appearance of the left humerus, originally interpreted as possible osteitis deformans, he was evacuated through medical channels to the United States, arriving at Brooke Army Hospital, Fort Sam Houston, Texas, on December 31, 1952.

Physical examination on admission: His cardiac condition had been adequately treated before his arrival in the Zone of the Interior. There were no palpable enlarged abdominal viscera. The only positive finding was the examiner's impression that the left humerus felt wider, by palpation, than the right. The patient had no complaints referable to the left arm on his arrival at Brooke Army Hospital.

Laboratory examination: The patient showed persistent eosinophilia, between 3 and 6 per cent. Urinalysis and serological studies were negative.

Total protein	7.03 milligrams per 100 cubic centimeters
The ratio of albumin to globulin was 2 to 1.	
Serum calcium	11.6 milligrams per 100 cubic centimeters
Inorganic phosphorus	2.0 milligrams per 100 cubic centimeters
Alkaline phosphatase	6 to 8 Bodansky units

Liver-function tests gave normal findings. The stools showed rhabdoform larvae of *Strongyloides stercoralis*. The complement-fixation test for echinococcus was negative. An electrocardiogram revealed complete right bundle-branch block.

Although the complement-fixation test for echinococcus was negative, the intradermal test of Casoni was not carried out. This was due to the inability of the authors to procure the necessary antigen for the test during the time this case was available to them for study. Another possibility, the test of Culbertson and Rose, utilizing the antigen of a related cestode, *Dipylidium caninum*, as reported by Howorth, was unfortunately overlooked by the authors while this patient was under their control.

Roentgenographic examination: Chest roentgenograms revealed dilatation of the aorta, slight enlargement of the cardiac shadow, and increased pulmonary markings. Roentgenograms of the left humerus revealed a thickening of the cortex and multiple areas of radiolucency. The entire humerus was involved (Figs. 1 and 2). The skeletal survey was negative.

Course in hospital: A biopsy was performed on the distal five centimeters of the left humerus through a posterior triceps-splitting approach on January 29, 1953. A block of bone, 1.0 centimeter square, with marrow attached, was cut and fragmented badly upon removal. The bone was a dirty, streaked, gray color and the fragments felt extremely gritty. The patient made an uneventful recovery. He lost no muscle power or range of motion and needed no physical therapy. He was transferred to a United States Army Hospital in Puerto Rico for final administrative disposition.

No drug therapy was attempted at Brooke Army Hospital, as no drugs now known are efficacious in this disease. As the patient was completely asymptomatic and the finding of osseous hydatidosis was an incidental one, we did not feel we should urge him to undergo disarticulation at the shoulder, although this seemed to be the only solution if we hoped to prevent extra-osseous spread of the echinococcus infection in the future.

When he left this Hospital, no laboratory, roentgenographic, or physical evidence of other areas of echinococcus infection were demonstrable. A follow-up report from Rodriguez Army Hospital, San Juan, Puerto Rico, in October 1953, stated that he still had no obvious systemic or local spread and was in good health.

Microscopic examination: Multiple sections were prepared from the bone fragments, hematoxylin-eosin stain being used. Microscopically the picture was that of many microcysts which partially occupied the marrow space of the bone and appeared within the lacunae (Fig. 3). The remainder of the marrow space was made up of fibrous tissue with marked lymphocytic infiltration (Fig. 4). Occasionally foci of granulomatous inflammation with multinucleated giant cells were noted (Fig. 5). The cyst wall consisted

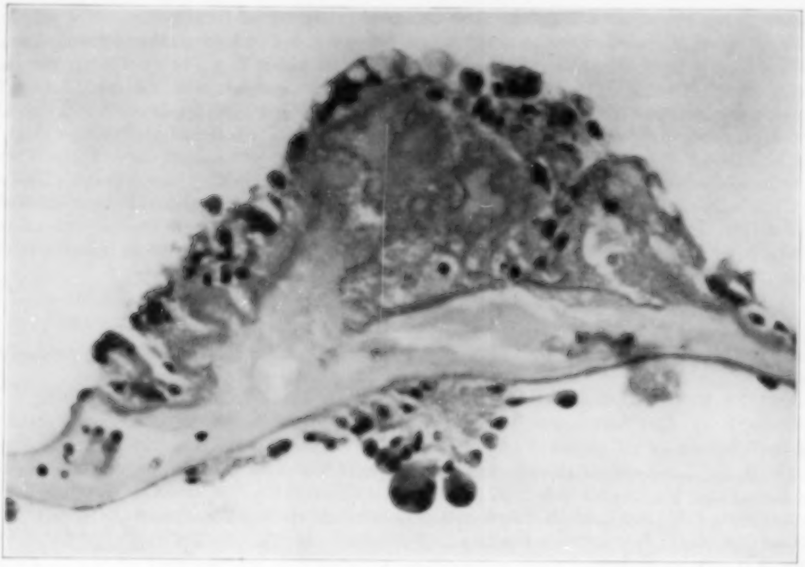

FIG. 7

(Br. 11222-3.) Photomicrograph (× 437) showing pyramidal architecture with maturation.

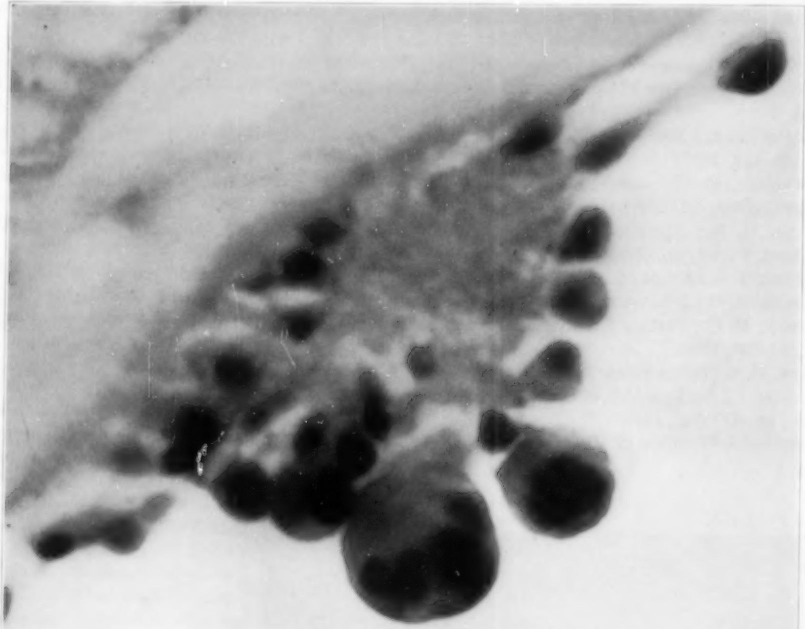

FIG. 8

(Br. 11222-2.) Photomicrograph (× 650) showing pyramidal architecture with maturation.

of a pale acidophilic material which was non-refractile and appeared somewhat collagenous in nature. This wall varied in thickness and occasionally appeared faintly layered (Fig. 6). External to the cyst wall an inflammatory-cell infiltrate was noted, which consisted principally of lymphocytes, some plasma cells, and a rare eosinophil. Occasionally a rim of epithelioid cells was noted adjacent to the cyst wall. Vascularity was not notable. On the inner aspect of the cyst wall there was generally a single-cell layer, varying from cells which exhibited scanty cytoplasm to cells which appeared somewhat columnar, with foamy, faintly pink-staining cytoplasm. Occasionally throughout the section reviewed there appeared to be an area which exhibited focal piling-up of the basal layer of cells into a somewhat pyramidal architecture (Fig. 7). At the apex of this pyramid the cellular elements were increased in size and stained more deeply. These cells were rounded and exhibited as many as four nuclear masses which stained a deep blue. The cytoplasm stained magenta. The edge of the cell which remained in contact with the pyramid appeared to have a pedicle-type attachment (Fig. 8). Microscopically the appearance was that of a microcystic process with an internal germinating layer consistent with hydatid disease of bone. The reaction of the bone to this process appears to be that of pressure atrophy.

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BILATERAL TRAUMATIC POSTERIOR DISLOCATION OF THE HIP COMPLICATED BY BILATERAL FRACTURE OF THE FEMORAL SHAFT

Report of a Case

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The combination of bilateral traumatic posterior dislocation of the hip and bilateral fracture of the femoral shaft has not been reported previously, so far as the authors know. This case is presented for this reason and because of the excellence of the result from treatment.

CASE REPORT

This seventeen-year-old white male was first seen on November 24, 1951, approximately five hours after the automobile in which he had been riding in the right front seat was struck head on by another vehicle. The patient had been driven forward by the impact, so that his knees had struck the dashboard, and then his body had been thrown through the right front windshield.

Upon arrival at the Clinic, he was somewhat disorientated and was in mild shock, but he was conscious. In addition to the mild cerebral concussion, multiple contusions and abrasions, he was found to have sustained bilateral posterior dislocation of the hip and bilateral fracture of the femoral shaft. The closed fracture of the left femoral shaft was in the proximal portion of the middle third, while on the right the fracture was open, the proximal fragment penetrating the skin through a pin-point opening at the junction of the middle and distal thirds of the femoral shaft.

It was noted that he was unable to actively dorsiflex the left toes or ankle. Thomas splints were applied bilaterally, and the patient was admitted to the Hospital, where he was treated for shock and examined for the head injury.

Approximately twelve hours after the injury, the patient was anaesthetized and manual reduction of the dislocated hips was attempted without success.

Therefore, another method of manual reduction was tried. A large Steinmann pin was inserted through the left greater trochanter in an anteroposterior direction (Fig. 1). Large vice-grip pliers (Fig. 2) were then clamped to the Steinmann pin anteriorly and posteriorly at the skin edge. Skeletal traction with this device was instituted with the proximal fragment in a position of flexion and adduction. While an assistant stabilized the pelvis by manual pressure on the iliac crests and anterior superior iliac spines, the surgeon effected the reduction by strong manual traction on the proximal fragment in the position of flexion and adduction for approximately five minutes. The reduction was accomplished with an audible snap, and the joint was stable after reduction, by clinical and roentgenographic examinations. The Steinmann pin was then cut at the posterior skin edge, a drill was attached to the projecting anterior end of the Steinmann pin, and the pin was removed in the usual manner. The same procedure was then carried out

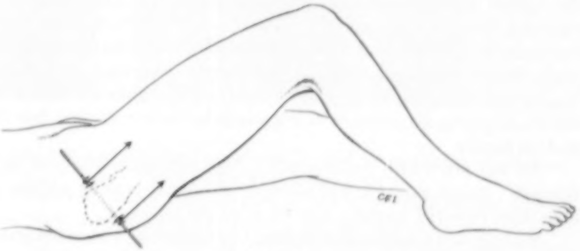

FIG. 1
Showing Steinmann pin in position.

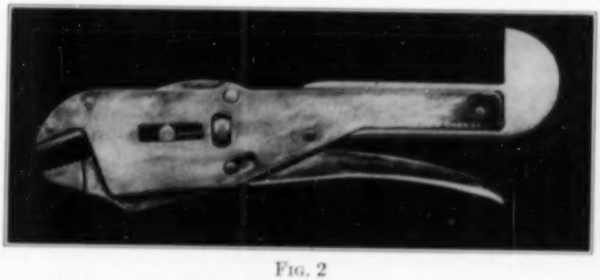

FIG. 2
Vice-grip pliers.

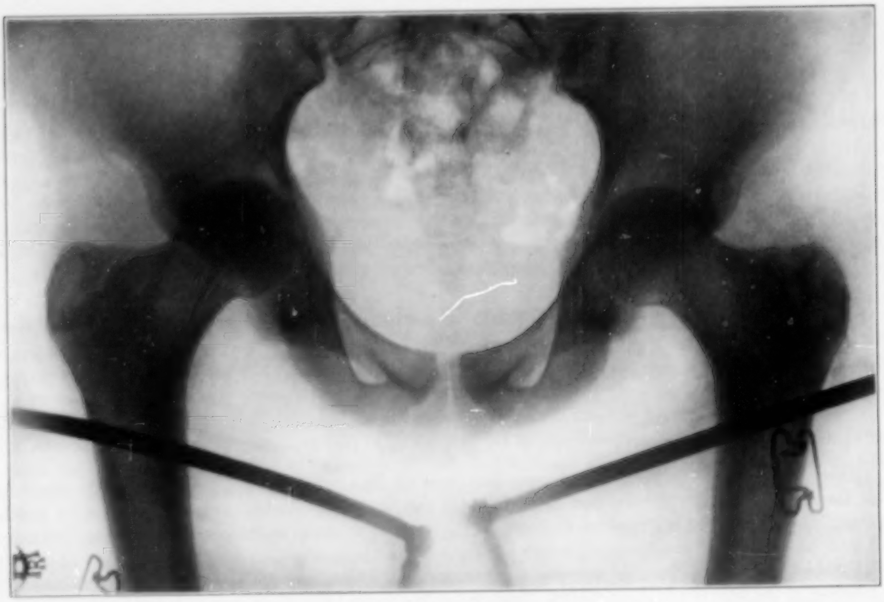

FIG. 3-A

Shows posterior dislocation of both hips.

on the right hip with successful reduction after two or three minutes of manipulation and traction.

Both lower extremities were then immobilized in balanced suspended Thomas splints with the hips in extension and abduction. The patient's course after this procedure was entirely satisfactory. After his sensorium had cleared, it was apparent that there was an incomplete paralysis of the left sciatic nerve which had undoubtedly been present since the time of the injury.

It was decided that medullary nailing would be the most satisfactory treatment for both femoral fractures. Therefore, on the sixth day after the injury, medullary nailing was performed on the left, followed on the eighteenth day by medullary nailing on the right, clover-leaf nails being used on both femora. Ten days following the latter operation (a total of twenty-eight days after the injury) the patient was discharged to his home on a program of non-weight-bearing exercises to strengthen the musculature and to mobilize the joints of both lower extremities. Three months following injury, it was noted that the femoral fractures were healing satisfactorily but that there had been no significant improvement in the incomplete paralysis of the left sciatic nerve. Exploration of the sciatic nerve was advised, but this procedure was refused by the patient and his family.

He was fitted with crutches and a drop-foot ankle brace for the left leg and was instructed in a "swing through" crutch gait. He was allowed full weight-bearing without crutches at six months. The medullary nails were removed fourteen months after the injury.

Twenty-one months after injury, the patient had regained complete range of motion in both hips and knees (Fig. 6). The only source of disability was the incomplete paralysis of the left sciatic nerve, for which he had refused surgical intervention. The femoral fractures were solidly healed in excellent position.

Roentgenograms (Figs. 5-A through 5-E) of the hip revealed no arthritic changes and no avascular necrosis of the femoral heads. There was slight periarticular calcification in the area of the right hip, which was asymptomatic. The extremities were equal in length, and he had been walking without support or a brace and engaging in essentially normal activities for several months.

Thirty-two months after the injury, the hips continued to be asymptomatic.

DISCUSSION

Key and Conwell estimate that dislocation of the hip accounts for between 2 per cent. and 5 per cent. of all dislocations. In three large series[2, 12, 13, 14] of cases of dislocation of the hip, simple dislocation of the femoral head was found to have occurred in between 21 per cent. and 46 per cent., the remainder being associated with fracture of the femoral head or the acetabulum. In 1936, Marquardt reviewed the entire world literature and found

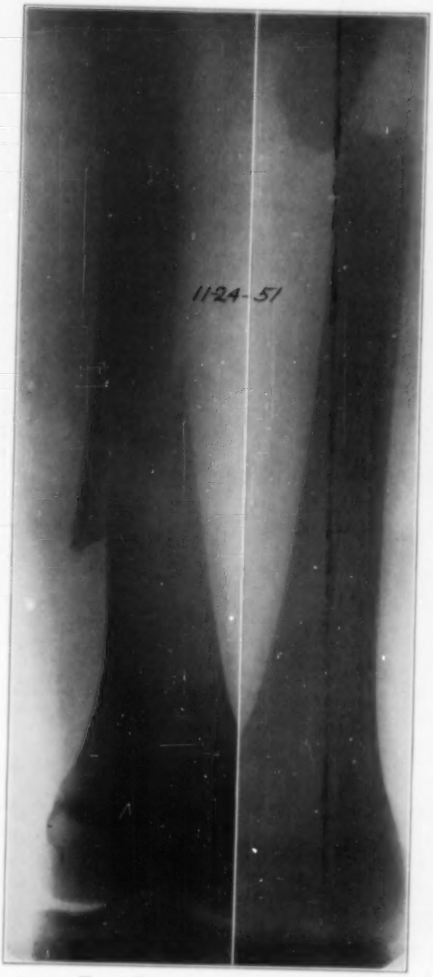

FIG. 3-B FIG. 3-C

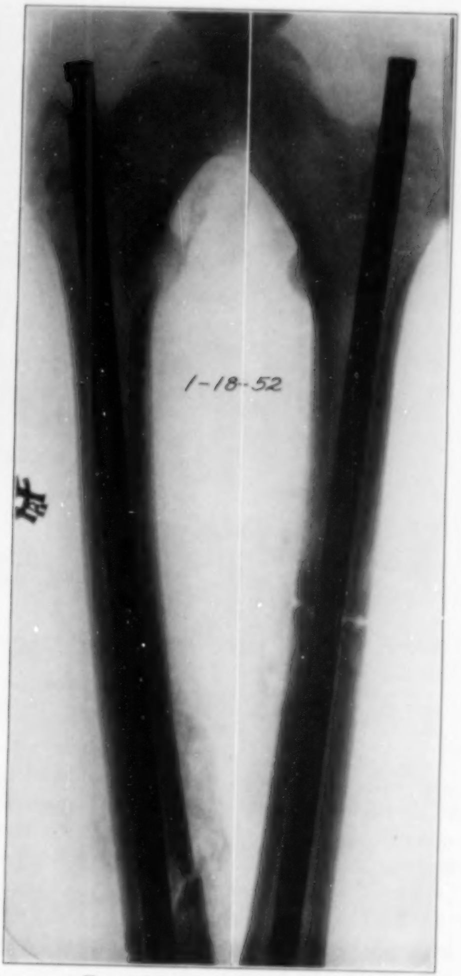

FIG. 4-A FIG. 4-B

Fig. 3-B: Fracture of the right femoral shaft at the junction of middle and lower thirds, which was open, the proximal fragment penetrating the skin through a pin-point thigh wound.

Fig. 3-C: Closed fracture of the left femoral shaft at the junction of the upper and middle thirds.

Figs. 4-A and 4-B: On the sixth day after injury, medullary nailing was performed on the left side (Fig. 4-B), followed by the same procedure on the right side (Fig. 4-A), eighteen days after injury. The fractures healed uneventfully, and the nails were removed fourteen months after injury.

only fifty-three cases of bilateral traumatic dislocation of the hip. A few cases [1,2,3,5,11,16] have been added to the literature since, but in none has there been associated fracture of the femoral shaft on either or both sides. Peterson reviewed the literature and found a total of thirteen dislocations of the hip complicated by fractures of the femoral neck; to this number he added reports of two cases of his own. Riggs and Slocum have reported a case of dislocation of the hip complicated by intertrochanteric fracture. Dehne and Immermann reviewed twenty-six reported cases of dislocation of the hip complicated by femoral-shaft fracture on the same side and added sixteen cases to the literature on the subject. In no published case did the combined injury occur bilaterally. In approximately 50 per cent. of the cases, the hip dislocation was overlooked at the initial examination, and in some cases the diagnosis was not established for several months after injury.

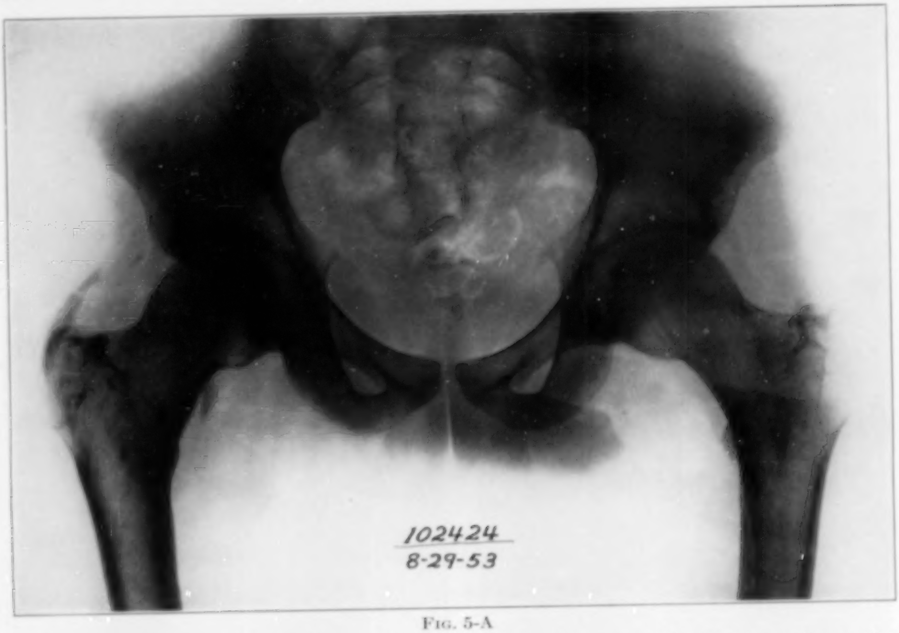

FIG. 5-A

Roentgenogram of the hips made twenty-one months after injury revealed no evidence of avascular necrosis of the femoral heads and no arthritic changes. There was some periarticular calcification about the right hip which was asymptomatic.

This combination of injuries is caused by two rapidly successive traumata according to Henry and Bayumi. In the case reported here, it is likely that the bilateral dislocation was sustained when the patient's knees were driven against the dashboard of the automobile, and the femoral fractures were produced a moment later when his body was thrown through the windshield of the automobile by momentum.

This combination of injuries should be suspected when the proximal fragment of a femoral-shaft fracture is fixed in a position of flexion and adduction, when there is a mass palpable in the buttock, or when the femoral-shaft fragments fail to align upon application of traction. Roentgenographic examination of the hip joint establishes the diagnosis.

Recent authors have shown conclusively that promptness of reduction of traumatic dislocation of the hip is the greatest determining factor in the results. Thus, the sooner the dislocated hip is reduced, the better the result is likely to be. The longer the hip is left unreduced, the greater the incidence of avascular necrosis and traumatic arthritis. For this reason, primary consideration in treatment of a dislocation of the hip associated with fracture of the femoral shaft is prompt reduction of the dislocation. Definitive treatment for the femoral fracture can be delayed without jeopardizing the result, as is demonstrated in this case.

It is generally agreed that closed reduction is more easily accomplished if it is done early than if it is done late, and also that the results following closed reduction are better than those following open reduction. When the dislocation is complicated by a fractured femur, manual manipulative methods have been unsuccessful in the majority of reported cases. Skeletal traction through the distal portion of the femur or proximal portion of the tibia is usually unsuccessful also. Successful attempts at closed reduction usually have utilized some form of skeletal traction applied to the proximal fragment, either by closed methods or by exposing the proximal fragment without opening the hip.

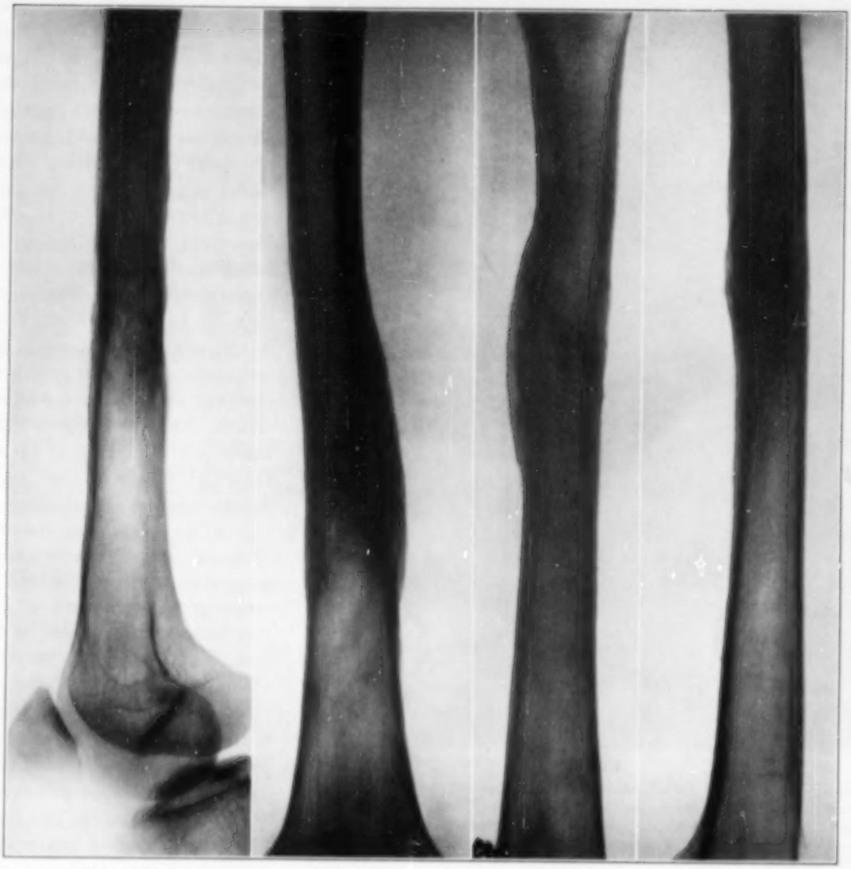

FIG. 5-B FIG. 5-C FIG. 5-D FIG. 5-E

Twenty-one months after injury, roentgenograms of both femoral shafts revealed solid union with no evidence of infection.

Dehne and Immermann reported an unsuccessful attempt in which lion-jaw forceps were applied to the exposed proximal fragment for traction and manipulation.

Henry and Bayumi used a variation of this technique of open exposure. Through an incision exposing the hip joint and including the femoral shaft, a strong wire was attached to the proximal femoral fragment through a hole made in the distal end, and traction was exerted while manipulation was being carried out. The dislocation was successfully reduced.

From the case presented here, as well as that of Wiltberger, Mitchell, and Hedrick, it appears that many such dislocations with associated femoral fractures may be successfully reduced soon after injury by the closed method of skeletal traction on the proximal fragment. These authors applied a two-pin, external skeletal-fixation apparatus to the proximal fragment to which they attached a section of pipe in the axis of the femoral shaft. Traction and manipulation by means of the Bigelow technique resulted in satisfactory reduction.

The technique used in the case presented here was very simple in that a single Steinmann pin was introduced in an anteroposterior plane through the greater trochanteric

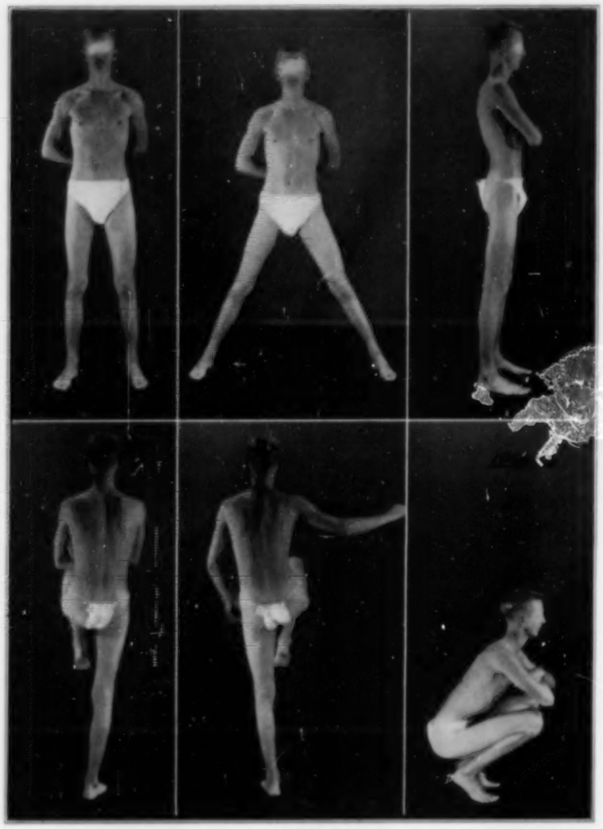

FIG. 6

Photographs taken twenty-one months after injury demonstrate complete range of motion in both hips and equal lengths of the lower extremities. The only residual disability was incomplete paralysis of the left sciatic nerve with mild drop-foot which did not require the use of a brace.

region in the proximal fragment. The use of large gripper pliers on the Steinmann pin facilitated traction and manipulation of the proximal fragment. It should be emphasized that a strong Steinmann pin must be used, since one attempt with a smaller, less rigid pin resulted in its bending. The application of skeletal-traction apparatus directly to the proximal fragment, without exposing the fracture site and without opening the hip, is a method which has obvious advantages and which can be attempted easily before more drastic means are utilized.

After reduction of the dislocation has been achieved, attention can be directed to treating the fracture of the femoral shaft. In most of the cases previously reported either skeletal traction or open reduction with plate fixation has been used. In a few of these cases, bone grafts have been applied primarily. Both of these procedures have been associated with a fairly high incidence of non-union or delayed union, as well as with joint stiffness from prolonged immobilization.

According to Speed, Stewart, and Milford [11], who surveyed 128 hip dislocations, there is no need for prolonged immobilization of the hips. On the contrary, it appears that early motion in the hip joint is desirable to restore maximum function to the hip joints as well as to the knees. The use of medullary nails in both femora accomplished that purpose in this case.

CONCLUSIONS

The case reported exhibited bilateral posterior dislocation of the hip associated with bilateral fracture of the femoral shaft. It is believed to be the only such recorded case. An excellent result was obtained following closed reduction of the dislocated hips and secondary open reduction and medullary nailing of the femoral fractures.

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ACTINOMYCOSIS OF THE HUMERUS

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Although medical literature contains numerous references to actinomycosis, as witnessed by the collection of 670 cases by Sanford and Voelker as early as 1925, few cases have been reported which do not primarily involve the cervicofacial, thoracic, or abdominal regions of the body. Classification of cases of this disease has been based upon infection of these three areas.

However, unusual forms of human actinomycosis do occur. Primary involvement of the skeletal components of the extremities has occasionally occurred, and this form has been the subject of two types of reports. Cases of actinomycosis diagnosed by histological study and without culture are represented by the reports of Burrows and Davies. In contrast, Shelton, Garber, and Smith thoroughly studied a case of culturally proved actinomycosis of the knee joint.

In the report to follow, presented with culture studies, the diagnosis was initially suspected on frozen-section examination.

REPORT OF A CASE

Clinical Features

A white man, forty-four years old, entered the Cleveland Clinic in March 1952 with a history of insidious, dull, progressive pain in the right arm of three months' duration which had become constant; it was relieved by heat and aggravated by movement. His hand was swollen and he was unable to close it.

Positive physical findings were limited to the right upper extremity. The skin was somewhat mottled, and a tender, warm, firm mass was present over the anterolateral surface of the mid-shaft of the right humerus. The movements of the shoulder were restricted by muscle spasm.

Roentgenographic examination of the right humerus revealed the medullary cavity in the mid-shaft of the humerus to be widened and irregularly radiolucent. Soft tissues about the region were swollen (Fig. 1). In the right upper lung field, there was some increase in bronchial and vascular markings. There was a suggestion of a localized infiltrating lesion, involving the base of the right upper lobe in its mid-portion, associated with hilar adenopathy. A comparison of chest roentgenograms with those made a year previously revealed no change.

Laboratory examination revealed:

Hemoglobin	11.8 grams per 100 milliliters
White blood cells	9,050 per cubic millimeter
Blood sugar	82 milligrams per 100 milliliters
Alkaline phosphatase	4.5 Bodansky units
Sedimentation rate (Rourke-Ernstene)	1.3 millimeters per minute

A biopsy was performed to clarify the diagnosis, as a question existed as to whether the lesion were inflammatory or neoplastic. The lesion was saucerized as a result of the frozen-section findings.

Pathological Features

The tissue removed was firm, gray, somewhat translucent, and contained several small, yellowish foci. A frozen section demonstrated the presence of a "ray fungus" in a sea of leukoctyes and macrophages (Fig. 2). A tentative diagnosis of actinomycosis was made. Gram stains of the fixed tissue demonstrated ray forms with a pink-staining tangled mass of central fibers (mycelia) and a blue-staining peripheral margin of "clubs"; acid-fast stains were negative. The material was cultured both aerobically and anaerobically; a pure culture of an *Actinomyces* was isolated. The organism grew as small, white, fluffy, discrete colonies only in the anaerobic portions of thioglycolate broth tubes (Fig. 3). Some of the colonies grew to a diameter of one millimeter. Both the original isolation and the subsequent transplants required four days for the organism to become visible macroscopically in thioglycolate broth. On tryptose-proteose-peptone agar plates containing 1 per cent. dextrose,

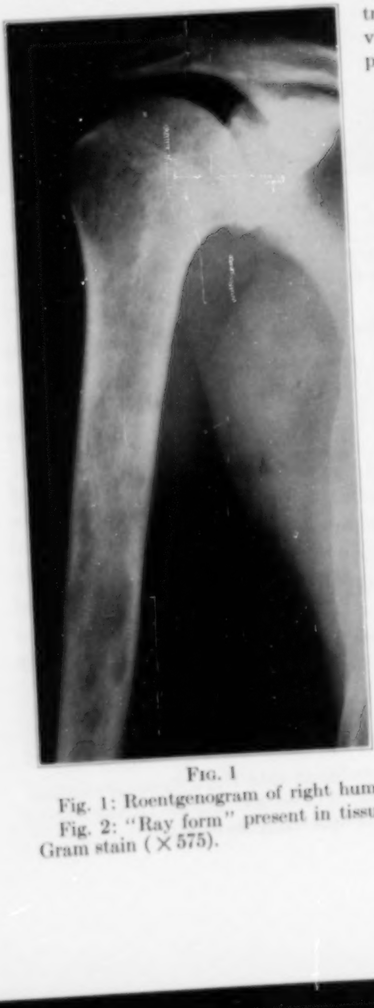
Fig. 1

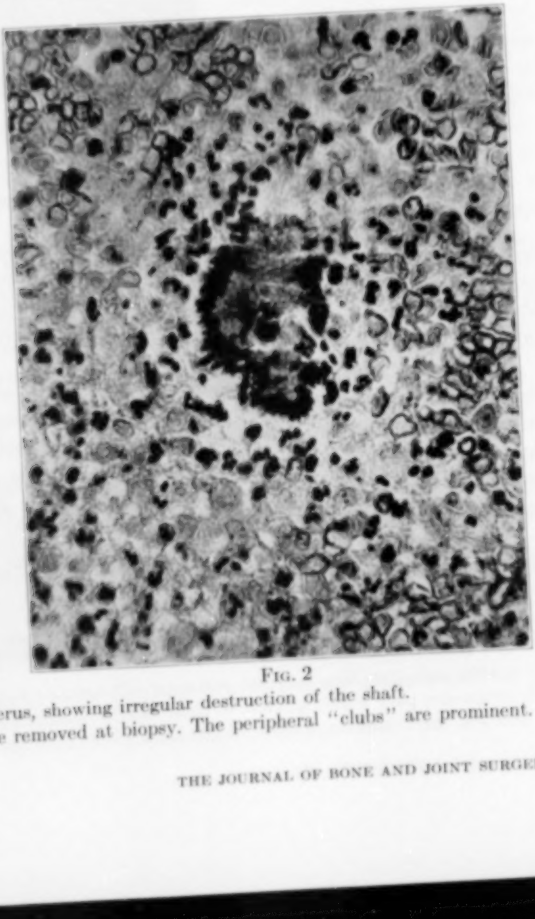
Fig. 2

Fig. 1: Roentgenogram of right humerus, showing irregular destruction of the shaft.

Fig. 2: "Ray form" present in tissue removed at biopsy. The peripheral "clubs" are prominent. Gram stain (× 575).

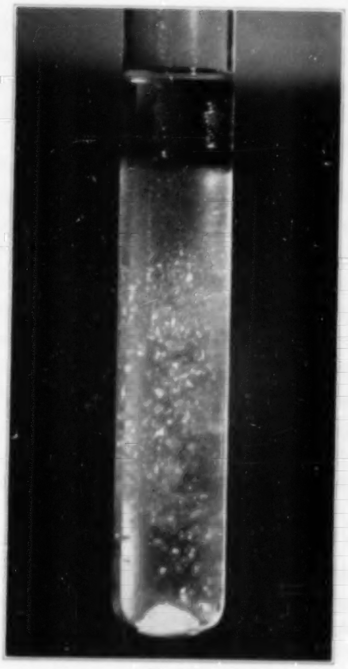

FIG. 3

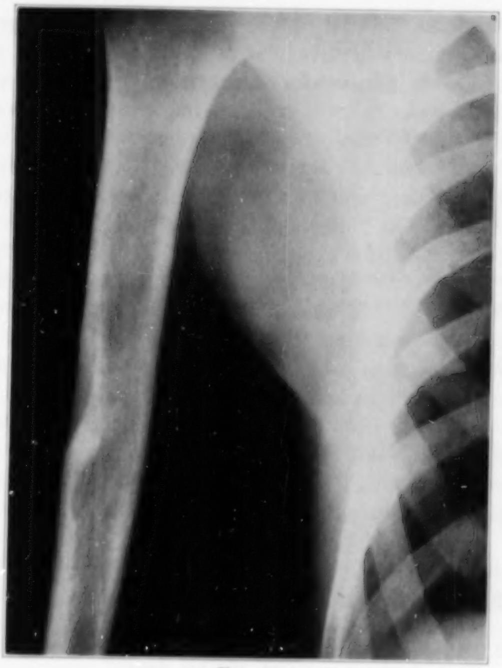

FIG. 4

Fig. 3: Thioglycolate-broth culture. Note absence of growth in aerobic portion (top) of tube.

Fig. 4: Roentgenogram of the humerus made eighteen months after Fig. 1. Note the healing that has occurred.

the organism, incubated anaerobically, slowly formed minute, faintly yellow, round, smooth, opaque colonies which did not penetrate the medium. The organism fermented only glucose and fructose from fructose, glucose, galactose, maltose, mannitol, lactose, sucrose, raffinose, and xylose. It was not proteolytic. Growth was inhibited in medium containing 0.024 units of penicillin per milliliter.

Massive penicillin therapy was instituted, and the patient received penicillin both as a catheter irrigation into the area of saucerization within the humerus and parenterally. He received a minimum of 1,200,000 units of systemic penicillin daily for a period of seventeen days, by which time his operative wound had closed completely. He was maintained on depot penicillin and received intramuscular injections at least twice weekly. The total penicillin dosage was 34,800,000 units. He also received sixty drops of a saturated solution of potassium iodide in divided doses daily for almost four months. The patient has now been asymptomatic for almost two years. Roentgenograms made at the end of eighteen months showed an apparently healed lesion (Fig. 4).

COMMENT

Several problems were encountered in the diagnosis of this patient's disease. In the most recent edition of *Bergey's Manual of Determinative Bacteriology*, the *Actinomyces* have been divided into the species *bovis*, chiefly pathogenic for animals, and the species *israeli*, chiefly pathogenic for man. The differentiating features predominantly concern colonial morphology: the *bovis* strains form a smooth colony and grow diffusely with the liquid medium: the *israeli* group develop a tough rugate colony which grows into the solid medium and forms a discrete growth in liquid medium. Thompson has recently studied several strains from both human and animal sources and has concluded that they were distinct species. Within limits, this particular organism seems to blend the morphological differences. In liquid media, it followed the growth pattern of *Actinomyces israeli*, but the colonial morphology was that of *Actinomyces bovis*. We have assigned a greater value to the appearance of this organism in solid media in classifying it as *Actinomyces bovis*.

Whether or not this lesion represents primary actinomycosis of the humerus is another problem. The changes shown in the roentgenograms of the chest suggested the possibility of a primary involvement of the lung. However, the chest lesion was relatively minimal, with static findings for at least a year prior to development of the bone lesion. The patient could produce no sputum on numerous occasions, and cultures of gastric washings were negative. Clinically, the disease manifested itself only as an osteomyelitis.

The initial recognition of the organism in frozen sections of the lesion greatly simplified the problem, although recognition of such a "ray" form only is an inadequate basis for the positive diagnosis of actinomycosis. Weed, Baggenstoss, and Baugher have demonstrated that other organisms, such as *Cephalosporium*, can mimic the formation of "ray" forms in tissue; occasionally no organisms can be cultured. In this particular instance, frozen-section examination provided information that prevented tissue fixation prior to adequate bacteriological studies. The often repeated statement that frozen sections are of little value in the diagnosis of bone lesions is false. In this particular case, rapid diagnosis at the time of operation provided a means of ensuring proper preservation of material necessary for adequate study. A histological diagnosis alone in such cases could be erroneous as to the exact nature of the offending organism. Therapy under such conditions might be poorly planned. The knowledge of the sensitivity of this organism to penicillin proved invaluable.

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SYMPOSIUM ON CRIPPLED CHILDREN'S SERVICES*

ALFRED R. SHANDS, JR., M.D., WILMINGTON, DELAWARE, *Chairman*

Many of you undoubtedly have wondered why this Symposium on the services of the crippled child has been included in the program for the Annual Meeting of The American Orthopaedic Association. The reasons for this are three: (1) the wish of your Joint Committee on the Public Care of the Crippled Child to present at a national meeting a discussion of some of the problems of the services for crippled children; (2) the desire of the Committee to bring representatives of the Children's Bureau into closer touch with the orthopaedic surgeons who are working with crippled children; and (3) the exceptionally deep interest in the problems of the crippled child which your President has had since 1937 when he became Medical Director of the Nemours Foundation, the work of which is entirely with handicapped children.

We are very honored and indeed fortunate to have at this meeting Dr. Martha M. Eliot, Chief of the Children's Bureau, as well as Dr. Arthur J. Lesser, Director of its Medical Services Division. It was thought that we should also have on this program a presentation of a good State plan in operation; so we have asked Dr. Herbert R. Kobes to come from Illinois. He is the director of one of the best State programs in the country.

Since there were to be foreign guests at this meeting, it was thought most appropriate to have the crippled children's services in their countries presented. So we have Mr. Mercer from Scotland, Mr. Malkin from England, and Dr. Garofalides from Greece as participants in this Symposium.

For some time many of us have felt that there should be a clearer interpretation to the orthopaedic surgeon of the rehabilitation of the whole child. This concept has been gradually developing during the last three decades and represents a great deal more than medical and surgical treatment. Out of this conference should come a comprehensive idea of this concept, as well as a better realization of our responsibilities to the crippled child. One of our distinguished members in discussing this problem recently said that it was time for the orthopaedic surgeon to realize that, if he is going to work with crippled children, he must be a sociologist, a psychologist, and a social worker. How many of us can qualify as such? It is my feeling that the answer is: "very few".

I hope that many of you will ask questions and take part in the discussion. Unfortunately, Dr. Eliot has to leave early; so, after she has finished, there will be a short discussion period, so that any of you who wish to ask her questions may do so.

In addition to the main speakers on the program, it was thought appropriate to have a word from one or two of the older members of our Association who have been working over the years for better crippled children's care; so we have asked Dr. George E. Bennett and Dr. A. Bruce Gill to speak. For many years Dr. Gill was Chairman of the Joint Committee on the Public Care of the Crippled Child, of which Dr. Green is now Chairman. Dr. Bennett was one of the original group who advised Dr. Martha Eliot in 1935 concerning the setting up of a program for the orthopaedic care of the crippled child in the Children's Bureau. I will call on Dr. Bennett to say a word first and to introduce our distinguished speaker, Dr. Martha Eliot.

DR. GEORGE E. BENNETT, BALTIMORE, MARYLAND:

As Dr. Shands was speaking about the question of the broad problem of the crippled child, I could not help feeling that back, way back, in 1910, 1911, and 1912, when I first joined Dr. Baer, there were many orthopaedic surgeons, he among them, who had a very broad point of view as regards the crippled child. I can recall very well that in one of our early talks he said, "Bennett, there are three phases to this: the rehabilitation of the crippled child physically, the education of the crippled child, and the vocational training". He said: "I think we've got to rehabilitate from the physical side; then will come the educational side; and then later, following that, will come the vocational training".

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* Presented at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 7, 1954.

There were a great many orthopaedic surgeons of the decade before us who were very much interested. This resulted in the development of two crippled children's hospitals in Baltimore, The Children's Hospital School and The Kernan Hospital, which have a sufficient bed capacity to take care of the crippled children of Maryland. The next move was also through Dr. Baer, in which the two schools for crippled children were developed. The last phase is that of vocational training—a problem which is still to be fully solved.

In 1935 I received a call from Washington from Dr. Martha Eliot and Miss Lenroot to appear before the Ways and Means Committee and to put up arguments as to why we should have money for the Children's Bureau for the care of crippled children. At a later date I was again consulted and was made a member of the original committee of advisors. The orthopaedic group consisted of Dr. Robert B. Osgood, Dr. Joseph A. Freiberg, Dr. Oscar L. Miller, and myself. I have had the opportunity of working with the Children's Bureau from the time it was organized. There were a great many problems to be worked out. Dr. Eliot and Miss Lenroot had a huge task in formulating the program and getting the ideas of all the people working on this problem. I think Dr. Eliot is to be congratulated for the excellent job she has done. It is a great pleasure to have the privilege of introducing her.

The Point of View of the Federal Administrator

BY MARTHA M. ELIOT, M.D., WASHINGTON, D. C.

I would like first of all to express my appreciation in behalf of the Children's Bureau to you orthopaedic surgeons for the magnificent service you have been rendering to handicapped children under the public and private organized programs for very many years. I know I do not need to refer to the devotion of the orthopaedic surgeons of this country, dating back many decades now, who laid the groundwork through voluntary efforts for the development of the public programs in the several States. I remember well the enthusiasm with which some of you in 1935 supported in Congress the passage of Title V of the Social Security Act, which has enabled all of the States to develop and extend programs for crippled children. This afternoon I want to give you a brief account of our stewardship and also to discuss some of the wider aspects of the work that seem important to us.

In the early years of the administration of the Social Security Act, many of you who are here today helped us to formulate standards of care which have served to improve greatly the kind of orthopaedic care given in many communities. The Children's Bureau was always deeply grateful for the time you gave in advising us and in developing and carrying out with the State agencies postgraduate activities to disseminate more widely the newer knowledge in orthopaedic surgery as it became available. As I think some of you know, we are looking forward to working with your Joint Committee with a view to putting into wider use some of the advances that are being made in the use of modern prosthetic devices. No doubt there will be still other ways of working together if we jointly seek them.

As the programs move forward and new men and women come into the field, new ideas develop, new ways of accomplishing old objectives are found. Sometimes wholly new concepts develop which illuminate the way ahead. The role of the Children's Bureau is not to dictate, but to give leadership to the State agencies in getting new ideas, in finding the way to work them out, and in doing a better job all the time on the older aspects of their work with children. In all of this, the Children's Bureau needs the help of technical experts like yourselves and of many other groups.

Those of you who participated in the steps that led to the establishment of the crippled children's programs under the grants to the States appreciate the considerable extension and the improvement in the programs which have taken place in the past eighteen years. You know, too, that the responsibility rests with the States for determining the types of crippling conditions which will be included, or, as the Act says, the "conditions that may lead to crippling". Though most of the States, as the State and Federal appropriations have increased, have extended their programs to groups other than the orthopaedically crippled, the latter still constitute by far the largest number (in 1952, over one-half) of children receiving physicians' services under the programs.

In terms of money expended by the States from Federal, State, and local sources, again much the largest proportion goes to the care of the orthopaedically crippled child and the child with cerebral palsy. You may be interested to know that in the fourteen-year period between 1940 and 1954 the Federal funds appropriated annually for crippled children's programs increased about two and one-half times, while the State and local funds increased more than four times. The stimulating effect on States and localities of Federal contributions to the public program has been very great. In this fiscal year, 1954, more than $40,000,000 will be spent to care for crippled children. Of this, the Federal funds appropriated for crippled children's services amount to $10,843,400. The States and localities are contributing $29,775,245, essentially three times as much as the Federal Government. The Social Security Act, as amended, authorizes the appropriation of $15,000,000.

In this same general period, as you know even better than I, voluntary contributions to programs for the care of children with poliomyelitis and other crippling conditions have been enormous. With the increase in funds for the public program, there has been a steady increase in the number of children cared for, until, in 1952, 238,329 children came under care. The rising costs of care have, however, meant that the increase in the number of children receiving care has not been commensurate with the increase in funds.

I have already pointed out that orthopaedic cases make up today over half of the total. In 1952, the second largest single diagnostic group of children cared for under the public programs was that of children with impairment of hearing. This group constituted, however, only 6.3 per cent. of the 238,329 children who received physicians' services through the program. In view of the interest that I know some of you have expressed, I have included the list of major diagnostic groups in 1952.

	Per cent.
Congenital malformations	21.5
Bones and organs of movement	19.0
Poliomyelitis	12.5
Cerebral palsy	9.4
Ear conditions	6.3
Burns and accidents	5.5
Rheumatic fever and heart disease	3.9
Eye conditions	3.2
Epilepsy and other diseases of the nervous system	1.5

The remainder (17.1 per cent.) includes a very small percentage each for tuberculosis of the bones and joints, birth injuries, and rickets, and, in addition, undiagnosed and miscellaneous conditions.

A gradual increase in the number of children with other than orthopaedic handicaps who receive care has come about as a result of the increases in funds for the programs, the interest of the Congress expressed in committee reports, and the considerable support given by parents, as well as by pediatricians and other medical specialists, to the inclusion of special types of crippling or handicapping conditions. The Children's Bureau has encouraged the States to broaden their programs when they have found it possible to do so. However, actually it is only the orthopaedic and plastic surgery services that approximate state-wide coverage today; the other types of service are still largely demonstration programs with very limited coverage. In addition to orthopaedic and plastic surgery, twenty-eight States include rheumatic fever demonstration programs; twenty-nine States, eye surgery; nine States, epilepsy programs; and fourteen States, service for children with impairment of hearing.

As the States have thus broadened their programs, new aspects of the problem of caring for such children have become evident. A number of State agencies define crippling in terms of those physical conditions which interfere with normal growth and development. Accompanying this is the concept that the degree to which a child is handicapped does not necessarily bear a close relationship to the extent of physical crippling.

The psychological effects of a handicap on a child and his family may be profound and often far out of proportion to the physical disability. The social problem that a handicap imposes on a child has long been recognized, but today, I am glad to say, both the social and the psychological aspects are better understood. The task of rehabilitation involves not only medical and surgical care but also a long period of learning by the child and his family of how to make the best of a difficult situation.

Medical and surgical treatment is usually the first step in helping the child to develop physically to his fullest capacity and to make a satisfactory social and psychological adjustment. While the program of care must be carried out under the leadership of the physician, many of the services essential to the child's satisfactory progress will be provided by the physical therapist, the medical social worker, the nurse, or the special teacher. The degree of insight of such a group of workers into the emotional, as well as the physical, effects of disability on the child's growth and development can make the difference between a handicapped but well adjusted child and one who is unable to make the psychological compensations necessary for a healthy personality despite maximum physical restoration. It is trite, perhaps, to say to a group such as you (but even so, I think it cannot be said too often) that teamwork among the staff is essential to optimal results. Likewise, we have to keep reiterating that the child himself and all his individudal problems must be the focus of attention, rather than the crippling condition alone.

The importance of prevention in the Crippled Children's Program is emphasized by the very nature of long-term illness. While the means of preventing the onset of many long-term illnesses are still few, the opportunities for limiting the progression of disability and for minimizing the unhappy psychological effects on the child and his family are considerable. The importance of the parents' role in reducing these effects of crippling has been given much greater recognition in recent years.

If parents are to give their crippled child the support that he needs, particularly while he is receiving medical and hospital care, they must have a thorough appreciation of what is involved and must understand more and more their own feeling about the crippling condition. Unless they do understand, it may be difficult, if not impossible, for most parents to have the confidence in themselves which is necessary to give their child the reassurance and the faith in them that he needs. This means that not only does there need to be ample opportunity for the parents to be given information about the physical condition of the child, but also opportunity for them to ask questions of the physician, the nurse, or the social worker about the total implications of the handicap and to have honest and full answers.

Many parents may, therefore, need skilled help in understanding their own attitudes toward their child and his illness. Feelings of guilt about congenital malformations or ideas that they have given inadequate attention to symptoms at the onset of an illness are common and lead to excessive anxiety. With help from the physician and, when possible, from a medical social worker, most parents become able to accept the realities of their child's handicap and to give him the strength he needs in living and growing up with his handicap. Many parents, as you know, gain much courage from meeting with other parents of handicapped children in groups, where they can discuss their problems together and benefit from group counseling. Such group discussions are being increasingly facilitated by the teams of professional workers in clinics and hospitals.

There is a considerable amount of attention being given currently to the ways in which the untoward effects of hospitalization, especially upon infants and young children, can be reduced. We know that separation from his mother may be profoundly disturbing for the infant or pre-school child and, if prolonged, may lead to personality disturbances which continue far beyond the immediate situation.

I would like to draw to your attention a most important document on this subject, a monograph by Dr. John Bowlby of the Tavistock Clinic in London, entitled "Maternal Care and Mental Health", published by the World Health Organization. In this article may be found a review of current research in the social sciences on this matter of maternal separation and its bearing on many problems of the care of children. A chapter on the care of maladjusted and sick children has many valuable suggestions for us.

In view of all we now know, it may be said with confidence that, if hospitalization is necessary for infants or children under six years, it is important that his mother be encouraged to be with him as much as possible. An increasing number of hospitals now not only permit daily visiting, but see the value of having the mother herself assist in the care and feeding of the young child. A few hospitals are even making facilities available so that the mother may stay continuously with the child through the hospital experience, or at least through critical periods. Any steps which will minimize the artificial nature of life in the hospital and will facilitate retaining close ties with the mother are of great value.

We also believe that convalescence at home should be encouraged whenever conditions permit. This usually involves help to the family by a social worker or public health nurse, who has a real understanding of the emotional as well as the medical problems involved in convalescence.

One of the major problems which all of this poses to you and to us is the problem of how we can manage to have good quality care, which we all want provided in hospitals, and convalescent facilities close to where children live in order to allow this very frequent contact with parents.

Children of school age need to have just as warm family ties when in the hospital or convalescent home as do their younger brothers or sisters, but they have wider interests and tolerate the separation better than the pre-school child. At school age, another problem arises,—namely, education for the handicapped child. It is our view that a young handicapped child should not be sent to a residential institution in order that he may receive education until every possibility has been exhausted for his education in his own community, where he can live at home with his family or in a foster home.

The departments of education in thirty-eight States are now making some provision for special education of the physically handicapped. Some crippled children are receiving their education in regular classes in day schools, some in special classes, some in special day schools for the handicapped, some in residential schools, some in hospitals and convalescent homes, and some in their own homes. However, few, if any, communities are providing this complete range of services. It is being increasingly accepted that many, if not most, handicapped children do well in regular schools, with such adaptations of curriculum and provision for special instruction as may be needed, in special or regular classes or in a combination of both. This does require considerable flexibility in school administration, an adequate guidance service, and teachers trained in the education of exceptional children.

The school situation which is best has to be decided individually for each handicapped child. Unfortunately, many crippled children still live in communities where there is not much choice and where the provision for special education is decidedly limited.

A great deal of the development and expansion and improvement of the Crippled Children's Program is the direct result of research, not only research in medicine and surgery and the biological and social sciences, but also in closely allied fields, such as electronics and mechanics. It is not a coincidence that the programs for hard-of-hearing children began their major development after the War. This was, in considerable measure, the result of the development of the new electronic hearing aid and new hearing-testing equipment, as well as the availability of chemotherapeutic and antibiotic agents. Children have benefited enormously from this research, much of which took place in Army and Navy hospitals.

Similarly, we are now witnessing the planning and preparation of new arm prostheses for children, based directly on the remarkable artifical limbs made for veterans. We are hopeful that children will benefit in the same way from this research.

Since 1945, a great deal of research on the problems of the amputee has resulted in a wealth of scientific information regarding the adult amputee and his problems. Within the past year, the National Research Council has become interested in the problems of the child amputee. The Children's Bureau is cooperating with the Research Council in every way possible. Some of you have written to us telling of your particular interest in the child amputee. Much of the research which has already been done for the adult can be utilized for the child. At the present time, the hand developed by the Army Prosthetic Research Laboratory is being adapted to two smaller sizes which can be used for children. Research on the problems of the child amputee is presently being conducted by the Michigan Crippled Children's Commission at the Mary Free Bed Guild Convalescent Home in Grand Rapids, Michigan, and by the University of California, Los Angeles, and at the Marion Davies Pediatric Clinic in Los Angeles.

By putting the results of such research into operation through the organized Crippled Children's Programs, often with the assistance of or complemented by voluntary groups, the benefits of modern science are being brought to many children living in rural areas, as well as to those in urban areas, who would not otherwise be reached. It is only by such infusion of new knowledge that these crippled children's services can continue to be growing dynamic programs, well equipped to serve the needs of our children.

Finally, may I say that, in my remarks this afternoon, I have stressed the need for all of us to consider the social, the educational, and the emotional aspects of this program of care for crippled or handicapped children. I have done this because I believe that we cannot afford to overlook the part that these children and youths may play in the future when they as young adults join the ranks of citizens responsible for the stability of our Nation and for the type of leadership it will give in world affairs. The part that they will play will depend on what kind of people they become.

Though handicapped children may be a relatively small segment of the total number of children and youths, we must bear in mind that the total number of handicapped people whose handicaps started in childhood is not insignificant.

We have to remember also that physically handicapped children are particularly exposed to discrimination, isolation, and rejection by the community and even sometimes by their own families. We know only too well that any child who is rejected or who feels himself deserted by his family will find the road to a healthy personality a most difficult one.

Handicapped children, then, even more perhaps than normal children, need the bulwark of family trust, affection, acceptance, and support, if they are to avoid overt aggressive behavior, even delinquency, on the one hand, or the building of walls of defense by retreat within themselves on the other. This places a great burden upon all of us who have a part in guiding the future development of this program to continue to look at our procedures and practices. We must make sure that everything is being done that can be done to bring complete health to the children under care—health in the terms of the now well recognized definition of physical, mental, and social well-being, not merely the absence of disease or infirmity. This is the end which we seek; the means to this end are for us to design together.

Again may I thank you for giving us this opportunity to renew our active partnership in this great program.

DR. SHANDS: Dr. Eliot, we thank you very much for giving us this concept of caring for the whole child.

Now at this point, questions or discussion are in order. If anyone would like to ask Dr. Eliot any specific questions about the program of the Children's Bureau in Washington, or would like to say anything about any points which she has brought up, this is your opportunity.

DR. LEO MAYER: *Is it still the policy of the Bureau to leave pretty much to the States the local administration of the programs?*

DR. ELIOT: The answer to that question is "Yes, it certainly is". The States have the whole responsibility for developing the plan of action under this program, as many of you know. The Federal Government appropriates money to the Children's Bureau itself; this money is allotted, according to formula in large part, to the several States. The State agency responsible (and it varies in different States) draws up a plan, setting forth what that State would like to do. The Regional Staff of the Children's Bureau, who know the programs in the States, work with this State agency in helping it to develop this plan. Then the plan of the State agency must be approved by the Children's Bureau (at this time by the Regional Representative of the Children's Bureau), and it then becomes an operative plan. The operation of the plan itself and the program are entirely in the hands of the State. The Children's Bureau operates no individual programs in this field.

QUESTION from the floor: *What is being done with parents and parent groups in Crippled Children's Programs?*

DR. ELIOT: I think that that is a difficult problem. In recent years we have been finding that parents themselves are very much more receptive to exploring the problems which are involved in this field of handicapped children. A number of associations of parents have been springing up in different parts of the country, sometimes on a local basis, sometimes on a national basis, to consider how they, the parents, can participate in the programs. To answer specifically your question "What is being done?", our Staff and the State agencies certainly do encourage parent groups whenever they have a chance to do so.

QUESTION from the floor: May I ask one thing before Dr. Eliot leaves? *Do the programs cross State lines?*

DR. ELIOT: Yes. If the child is in a given State where a special type of crippling condition cannot be taken care of, then that State may send the child to another State for the type of care which that particular child needs. The State of origin may pay for the care of that child.

DR. WILLIAM J. STEWART: *As far as the Children's Bureau goes, is it true that the Bureau approves such expenditures?*

DR. ELIOT: Yes, that is entirely true. Once the money reaches a State treasury, it is used by the State under the fiscal laws of that State. If a State has some law which is limiting, then it is up to that State to modify its law so that it can provide a more liberal program for these children. I think that Dr. Lesser might at this point answer that question more specifically, if you would like to have him do so.

DR. SHANDS: Dr. Lesser, will you say a word?

DR. LESSER: I am very happy to have the opportunity to speak to you. I am glad that this question was brought up, at least modifying somewhat Dr. Eliot's reply, because it is a very difficult question. In a few States, we still have State laws prohibiting the expenditure of funds of that State in another State. There have been occasions when some of the States have used some of the Children's Bureau Federal funds under such conditions. On the other hand, an attorney-general, at another time, may say that this cannot be done, whether Federal funds or State funds are concerned. All funds have to be spent according to State laws. It is a matter of interpretation of the individual State. Now, for an example, that of the treatment of children with congenital heart disease. A few years ago, there were relatively few places which were equipped to make the diagnosis and to provide the surgical treatment. Today, there still are a number of States where there are no hospitals with staff and facilities for this work. The Children's Bureau has, by making a grant to a State specifically for this purpose, made it possible for a State, such as Illinois, to provide and pay for care in a hospital in Chicago for children living in neighboring states, such as South Dakota, where it is not possible for the child to receive surgical treatment for congenital heart disease. In the discussion we had this morning with the Joint Committee on the Public Care of the Crippled Child, the suggestion was made that, possibly, in the beginning of work with these upper-arm prostheses, a similar regional type of center might be developed.

May I also add, in response to another question, that the Children's Bureau, in response to many, many letters which we have received from parents about their children's crippling conditions, has published in recent years a number of pamphlets for the public, dealing specifically with handicapped children of various kinds, and these have had a very wide distribution and an excellent reception. I think there is no doubt that the problem of dealing with parents is not always an easy one, particularly when parents' groups are organized quite aggressively, as sometimes they are, in behalf of a particular group of crippled children. I think that, given opportunities to work with the public and private agencies, eventually such groups become a strong asset and a strong support of the program, lending great assistance. They certainly have been of great assistance to the Children's Bureau and to many State agencies in their support of the Crippled Children's Program, enabling us to speak to the Congress in order to obtain help in the extension and further development of these programs.

QUESTION from the floor: *Are the Children's Bureau funds being used for custodial care?*

DR. LESSER: I do not believe that the funds made available to the Children's Bureau are being used for outright custodial care if, as I understand it, custodial care is considered to mean room, board, and minimal bed care—that is, attendant care—of a child in an institution where very little medical care other than practical nursing is being provided. It is questionable that the Social Security Act would permit our funds to be used for that purpose. However, it is a good point, and it has been brought to our attention frequently that there is a considerable need for assistance for such children. Of course, in many States, it is possible that there are other funds; some State welfare funds are being used for this purpose.

DR. SHANDS: Thank you very much, Dr. Eliot and Dr. Lesser, for giving us this interpretation of the Crippled Children's Program.

Now, the next part of the program is to obtain the point of view of a State administrator. Dr. Kobes has come from Illinois and is going to tell us about his program.

ADMINISTRATION OF A STATE CRIPPLED CHILDREN'S PROGRAM

BY HERBERT R. KOBES, M.D., SPRINGFIELD, ILLINOIS

Crippled Children's Programs as administered as a function of State government first came into being shortly before the turn of the century, when Minnesota developed such a program to meet the needs which had been presented to the people of that State. Between that time and 1935 when the Social Security Act was passed, thirty-seven States wrote various kinds of laws related to crippled children. Actually, in 1935, very few States had a well rounded or complete program of services for crippled children. Within a few years after 1935, all of the States and Territories and the District of Columbia had the equivalent of a statewide program for services for crippled children.

The programs are found in various branches of State government. The majority of them are found in departments of health, because of the logical relationship of a medical-care program to the over-all sphere of activity of the health department. Among the States that had programs prior to 1935, many of the programs were to be found in other departments of government—in the departments of welfare and education, and in independent crippled children's commissions. It is of interest to note that at the present time the Crippled Children's Programs in four States—Oregon, Iowa, Missouri, and Illinois—are related to the State's university or the State university's medical school. The program in Illinois will form the basis for most of this discussion.

Because of the stimulus of the Social Security Act with grants-in-aid specifically for Crippled Children's Programs, a pattern for State and Federal relationship has been established. That the States have accepted a Crippled Children's Program as a distinct responsibility of the State is shown by the fact that over the last twenty years an increasingly greater proportion of all of the public crippled children's funds have been appropriated by the States from their own resources. In addition to the grants-in-aid from the Children's Bureau of the Department of Health, Education, and Welfare, a great deal of service is made available to the States through help in program-planning and by the furnishing of consulting services. The Children's Bureau and its Staff are to be greatly praised for the immense amount of help which has been given to the States in terms of raising standards and otherwise giving a stimulus to improve resources for crippled children in the various States dependent on their own needs and abilities. The Children's Bureau has had help from its own National Advisory Committee. Several members of this Association have served on the Advisory Committee.

No definition of a crippled child has been written into the Social Security Act, and the Children's Bureau itself has never felt that it could write a definition of a crippled child. Each State has had to write its own definition. In some States the definition is written into the law, and in others the definition is created on the administrative level. The States having the programs with the narrowest scope are usually those in which the definition is written into the law and is not changed readily as needs vary. These States usually emphasize the program for children with orthopaedic handicaps and with handicaps which can be ameliorated by plastic surgery.

When the program became available to all of the States, the philosophy of treating the whole child was beginning to be popular, and this stimulated consideration of the various needs, other than hospital and surgical care, which are recognized whenever one meets the problem of serving crippled children. At this point, the pediatricians became more prominent in Crippled Children's Programs, and it is a matter of record that the medical directors of services for crippled children at the present time are predominantly physicians who have been trained in the field of pediatrics. Many of these physicians have been certified by The American Board of Pediatrics.

In conformity with the Social Security Act, the programs in the States are to be made available to all children, regardless of race, color, creed, residence, and economic status. Certain State laws and the unavailability of facilities may prevent uniform application of the law, but it is fair to state that, within the limits of the available funds, children have had a reasonably good opportunity to obtain care in all States.

In the State of Illinois, the Division of Services for Crippled Children makes available a program for children under a limited category of medical conditions, but the administrative definition which is used in the program states:

> "A crippled child is any child up to the age of twenty-one years of age, who is crippled or physically handicapped or who suffers a condition which may lead to crippling or to a physical handicap, and whose condition is such that he requires specialized medical and related care which may reasonably be expected to cure or to materially improve his condition or to prevent further progress of the handicapping condition."

Because of the amount of funds available, because it is difficult to recruit well qualified persons for the staff beyond the number that we have available at the present time, and because our own Professional Advisory Committee has advised against extending the program to other medical categories without specific edict from the Legislature, the number of medical categories is relatively limited. Presently, the program is operated to render services to children who have orthopaedic disabilities; to children who have congenital or acquired defects which will respond to plastic surgery; to children with rheumatic or other types of heart disease, including congenital heart disease which is amenable to surgery; to children with neurological disturbances, including cerebral palsy and epilepsy; to children with hearing loss and deafness; and to children with speech defects associated with organic defects. It is true that in other States additional groups are covered within the Crippled Children's Program, but actually very few States have as broad a range of medical categories or medical and related services as does the State of Illinois.

As you probably know, rather consistently throughout the Nation, because of one of the Children's Bureau's regulations, diagnostic services are available to crippled children without charge, while treatment services are handled on the basis of providing State resources for those who need help. The very logical difference relating to diagnostic and treatment services is based on the amount of money available and the fact that, without a diagnosis, no program of care for any child can be planned.

We believe that the Illinois program is a good example of the range of staff that is needed to carry out an effective Crippled Children's Program—a program which will have as its objective the improvement by medical and other means of the condition of handicapped children so that, as they reach adult life, they may be fitted for positions which will make them useful members of their communities. The best Crippled Children's Programs are those which have full-time medical administrators who can plan the over-all programs and deal with consultants in the medical and other fields to develop specific programs to meet the needs of individual children. In some States, full-time specialists who are active in fields such as cerebral palsy, rheumatic fever, or in the problems of the child with hearing loss may be members of the staff of the crippled children's agencies. Such consultants, however, are not found very widely. The medical-staff members usually function as administrators. The clinical medical staff is a consulting staff and is usually made up of the best physicians in the various specialties who practise within the State. In the Illinois program, the basic requirement for a medical consultant is that he has been certified by one of the American Specialty Boards. We have had no problem in getting a sufficient number of physicians who meet these qualifications. As a matter of fact, in your own field of orthopaedics, we have many more orthopaedic surgeons certified in Illinois than could possibly serve as consultants to the Division of Services for Crippled Children. Our consultants come from the major teaching centers within the State and include also qualified physicians in private practices who are found in the communities outside of the teaching centers. There are in Illinois approximately a dozen communities that have one or more Board-certified orthopaedic surgeons practising in the community, and these orthopaedists are active in the Crippled Children's Program. We also function on the basis of trying to have continuity of medical service and, consequently, the orthopaedic surgeon who serves at the Division's field clinics, which are scattered throughout the State, also serves the needs of the patient in his office, when such supervision is needed, and in the hospital when surgery is advised. In other words, the orthopaedic surgeon may first see the patient on the referral of the family physician in a field clinic 100 miles or more from his own community. Next he sees the child in the community hospital where he practises. Follow-up after that may be given either in his own office or in the Division clinic, depending on the particular needs of the child.

We feel that our method of bringing specialist services to the patients and doctors in the local community is wise, and we know that it is well received, because we have found that a good many family physicians, especially in rural areas far removed from the usual specialist resources, send their patients who are crippled children to the Division clinics for original diagnosis and consultation. Treatment for these patients may be arranged through the resources of the Division, but the Division does not make payment for these services. The majority of our orthopaedic consultants have felt that this type of program is a reasonable one, because they are fully cognizant of the fact that there are often difficulties in getting specialist services in a remote area, and, thus, they are willing to make consultation available to physicians in the area. We have also found that our consultants are called by the local physicians for private service while the consultant is in the area, at a time apart from the time he spends in the clinic. It must be admitted that this type of additional service is a beneficial by-product of a State program for crippled children.

In Illinois, we have approximately 260 clinic sessions in about forty areas of the State. At these clinics, there are in attendance both a pediatrician and an orthopaedic surgeon. On the Division Staff, there are our own speech and hearing consultants who serve the area in which the clinic is held, public health nurses of our own Staff and from the staff of the local agencies, and, in as many areas as possible, a medical social worker who is one of our own Staff members. We feel that every new patient should have a good general review of his total medical and health status by the clinic pediatrician and, if his needs are in the field of orthopaedics, he is then placed under the charge of the orthopaedic surgeon for a definitive diagnosis and program of care. If a child has a hearing loss, he is seen by both the pediatrician and the speech and hearing consultants and is then referred to the otologist nearest his place of residence for a more complete otological examination and diagnosis. If medical or hospital care is needed, this can be provided. If a hearing aid is needed, the child is sent to one of several audiological centers; there, among other things, a hearing evaluation is made, in order to determine the particular type and model of hearing aid which will most nearly meet the child's individual needs. Training in the use of the hearing aid is always needed, and this can be provided through the audiological center, through teachers for the deaf and the hard-of-hearing in the local community, or through speech centers, where an intensive program is made available during the summer to children with speech and hearing difficulties.

The public health nurses are, next to the physician, the most important members of the team which provides services for crippled children. She has close contacts with both the families and the family physicians in her community. She knows what the State program can offer, what its standards are, and how and where services may be obtained. She acts as an effective liaison between the professional clinical consulting Staff of the Division and the family physician and the family. She is responsible for the activities which make certain that children keep their appointments both in hospitals and at clinics, as well as at doctors' offices, and she guides the family in the management of the home care which has been recommended by medical consultants.

When there are emotional and social problems, these frequently need to be referred to the medical social workers, who have done an admirable job in working with families, in order that they may be able to live better with their handicapped child and to take advantage of the services which are available and needed for him.

The speech and hearing consultants serve as diagnosticians in our clinics and then have the responsibility of making contacts with the otologists, the speech centers, speech teachers in the local communities, and other agencies or individuals who might help the particular type of children who come within their sphere of activity.

Other individuals, such as psychologists, nutritionists, health educators, various types of dental specialists, and physical and occupational therapists are brought in as deemed necessary for the individual cases.

One of the most important working relationships which we have established is that with the special education program. In Illinois, the special education program is set up with a consultant and advisory staff from the State office, which is able to render services to the local school districts. The local school districts have the responsibility of setting up and maintaining special education programs to meet the community needs. Because financial help is needed to make community programs available, the State Division of Special Education is able to make what are called "payments for excess cost of special education". This means that a school system needs to know what it costs to educate the average child in the schools and what it costs to educate the child who has special educational needs. The State, up to a limited maximum, can pay the difference between the two, or the excess cost. Illinois probably has one of the most highly developed special education programs of any State in the Nation. This program has resulted both from recognition that appropriations to conduct the program on the State level are needed and that trained supervisory or consulting staff is needed, in order that the local communities may be able to develop the kinds of programs that are necessary to meet the needs of the children living in those communities. The influence of an active crippled children's medical-care program in pointing up needs has also had a material effect.

Collaboration with other agencies is necessary, too. There are often social or child welfare services which are needed for crippled children. The Department of Public Welfare has facilities and staff which can be used to help crippled children. Also, many crippled children are in families receiving public assistance, and, by working with the social workers in these programs, crippled children's organizations can often make improvements which are in the interests of the child and the family. We cannot fail to point out that the success of any State Crippled Children's Program is almost directly dependent upon the quality and the amount of full-time health service which is available within the local jurisdiction of the State. In Illinois, we function under the philosophy that each crippled child lives within a local health jurisdiction and that his general health problems are the responsibility of the local health jurisdiction. The Crippled Children's Program furnishes a program with funds and other resources which the local community does not have; this program can best be administered from the State level. Responsibility for case findings and for most of the local follow-up through the public health nurses falls back on the local health jurisdiction. We have found that this close interplay between local and State agencies is very successful in bringing to the children a good program of care.

Many private agencies also work along with the Division of Services for Crippled Children in promoting the best possible program for children wherever they may be. Among these are The National Foundation for Infantile Paralysis, the United Cerebral Palsy Association, the local affiliates of The National Society for Crippled Children and Adults, and many others.

In Illinois, the Shriners and the Elks both have independent crippled children's programs. Children who are currently receiving care from these two groups do not become eligible for services by the State program, except when referral by the private organization is made to the State program. The Elks in particular have a program which is for the most part clinical, and the hospital and surgical care for their orthopaedic cases is provided either through the Orthopaedic Service at the University of Illinois teaching hospital, or through the hospitals providing care for the children under the Division of Services for Crippled Children. In the latter instance, the Division of Services for Crippled Children is responsible for payment of the hospital and medical services.

More and more facilities for partial treatment in local areas are being developed. In addition to the local follow-up by public health nurses, social workers, and speech therapists, we find that physical and occupational therapy services are becoming available as local groups set up treatment centers. The Division of Services for Crippled Children may purchase care from the privately conducted treatment centers, whether they be conducted by hospitals or independent agencies. Appliances, such as braces, artificial limbs, hearing aids, and dental prostheses, may be purchased through the use of the Division's financial resources. In all instances, financial need is determined on an individual basis with each family and for each item of care, because financial need does vary a great deal, depending upon the number in the family, the total income, and, more than anything else, the probable cost of providing care. We have found that, as the years go on, more and more patients are able to provide a greater proportion of the cost of their care as insurance, both hospital and medical, is purchased by a greater proportion of the population. Division funds are never used for purchase of care when resources within the family are available. A patient becomes economically eligible for Division care when it can be demonstrated that the family cannot provide the total cost of care.

In Illinois, payments are made to physicians who render service for the Division cases. Specified clinic fees are paid to those who serve in the clinics. In addition, they receive reimbursement for necessary travel expenses. When care is given in the doctor's office or the hospital, payments are made on the fee-for-service basis, and on what we recognize is a limited fee schedule.

The Division operates under the policy that prior authorization for care is both desirable and necessary, in order to eliminate the many unhappy circumstances which can arise when payment for care which does not meet the standards of the Division is requested. Just to give a brief capsule picture of the extent of our program, we might relate that in the present two-year period we are operating with a State appropriation of $3,000,000, and to this is added approximately $700,000 of money from the Children's Bureau. About half of that money is granted to the State on the basis of special training and educational programs and, consequently, does not go directly to the care of Illinois children. One of these, the Midwest Cardiac Surgery Program, is administered by our Illinois Division to provide cardiac surgery services in Chicago to children living in other States in the Midwest not having equivalent resources.

The full-time staff consists of three medical administrators, one of whom, however, is a full-time staff member of the University of Illinois College of Medicine, Department of Pediatrics. There are twenty nurses, six speech and hearing consultants, and seven medical-social consultants. In addition, there are other technical personnel, such as a photographer, statistician, business manager, and personnel officer. Clerical workers bring the total Staff to about 125. With this Staff and this amount of money, we render services to approximately 30,000 children who are actively on the register. Each year, approximately 10,000 of these receive some type of service which may vary from a single home public health nursing visit to expenditure of hospital and medical funds amounting to $4,000 or $5,000 for each child, if this is necessary.

We believe that the Crippled Children's Program is one which will always be with us, because there will always be problems that relate to this group of children. Families will need help through resources other than their own, because it is known that medical care for crippled children is both expensive and goes on for many years. As was indicated in the report of the Commission on Chronic Illness, "Chronic disease and poverty get to be synonymous sooner or later". There are many types of medical conditions, other than orthopaedic, which are of long duration and which cost the families tremendous amounts of money and energy. More research needs to be done, and a great deal of education among professional and lay people needs to be carried out, in order to develop the best possible program for each State.

An ideal Crippled Children's Program is one which has the broadest possible range of high quality medical care and related services available to meet the needs of children having a broad spectrum of medical diagnoses. These medical categories should perforce be those which are characterized by long duration of the effects of the handicapping condition and thereby cause an undue amount of drain on the family's energies and economic resources. Adequate payments should be made to all who render services, whether they be full-time staff members, or part-time consultants giving clinical services. All families should make payments toward the cost of care within their ability to pay. All personnel should meet the highest possible standards of professional ability and performance. The health and medical-care services needed to obtain the best clinical results for each child should be made available, and the social, emotional, educational, and vocational-training aspects of each child's needs should also be the concern of those who have the responsibility of administering the State's Crippled Children's Program. Whenever it is necessary to do so to ensure a wide range of capable services, the State should provide training programs to help fill any gaps which may be present. Existing resources should be used to the fullest extent and without duplication of services. They should be improved whenever necessary to meet the most desirable standards of care, and only when existing resources are definitely proved to be lacking, should completely new facilities be constructed. There needs to be sharing of resources among communities, even to the extent of working out interstate arrangements when it seems undesirable to make available for one State a service which may be used but rarely. Only when we know that we have a program which will bring the maximum number of physically handicapped children into our society as useful, productive members can we feel that our job is nearing its highest level of success and accomplishment.

We could not close this discussion without mentioning the notable report of the committee of which Dr. A. Bruce Gill was Chairman. You are familiar, I am sure, with the recommendations of the Joint Committee on the Public Care of the Crippled Child which were approved by the Executive Committee of The American Academy of Orthopaedic Surgeons in April, 1952. The orthopaedic surgeons have taken a commendable step in making the type of recommendations which were made within this report, and it is hoped that within the years ahead the orthopaedists will increase their interest and knowledge in the Crippled Children's Programs in their own States. This interest should be developed in terms of improving the standards for and, consequently, the quality of medical care, as well as improving the administration of the programs. It should make certain that all of those who really need help have it available in a way that befits the dignity of the community, the family, and the medical profession which is so important in providing care for this group of our citizens.

DR. SHANDS: Thank you very much, Dr. Kobes. You have given us exactly what we wished. Now I think, before we have discussion and questions of Dr. Kobes, we will ask Dr. Green to present the point of view of the orthopaedic surgeon. I think he may touch on some of the same points which Dr. Kobes has brought up.

THE POINT OF VIEW OF THE ORTHOPAEDIC SURGEON

BY WILLIAM T. GREEN, M.D., BOSTON, MASSACHUSETTS

When the Crippled Children's Program of the Federal Government was instituted in 1935, it was designed for the child who was crippled, the term being used as it had been used for centuries to describe what we might call the "orthopaedic cripple". In the development of this program, an advisory committee of orthopaedic surgeons worked in conjunction with the Children's Bureau in forming the basic plan. In the beginning, the activities of the Children's Bureau were viewed with considerable suspicion by many members of the medical profession in that they considered this a step in which the Federal Government was entering the practice of medicine. Orthopaedic surgeons of that period, however, had a very broad concept of their social responsibilities in the care of crippled children and they supported the program from the beginning. Orthopaedic surgeons, in fact, have always given freely of their time toward the care of the crippled child. They had aided in the enterprises of many endowed institutions and agencies in the care of the handicapped and in many other programs which were in existence prior to the Federal act which established the program of the Children's Bureau. These activities in the care of the crippled child have always been a subject of pride to orthopaedic surgeons, and they were prepared to support the Crippled Children's Program and to take what seemed to be a very large step in the practice of medicine of that period. It was a pleasure to hear Dr. Bennett's reference to the evolution of the program.

In this early period, the liaison between the Children's Bureau and the committee of orthopaedic surgeons was, as it has been described to me, quite close. I remember hearing of some of the discussions of that time from Dr. Robert Osgood, who was a member of the committee. As time went on, however, the association between the Children's Bureau and orthopaedic surgeons became quite tenuous. For one thing, the Children's Bureau became involved in other areas of activity, with increasing interest in various phases of maternal and child health. Furthermore, semasiology reared its head. The term "crippled child" received a new interpretation and was used to describe the child with any handicapping disease. Thus the services became concerned, for example, with the "cardiac cripple", with the "auditory cripple," and with children with other types of handicap. This broader interpretation of the term "cripple" seems entirely reasonable, but there was a feeling that the orthopaedic cripple was being gradually shunted from the main stream of activity. I am confident that the spokesmen for the Children's Bureau would say that this changing pattern of interest was an evolutionary one and that the purpose of the Bureau was to stimulate activity in new fields which needed stimulation. Be that as it may, there was a feeling among many orthopaedic surgeons that not only had the orthopaedic cripple lost his rightful place in the program but also that the counsel of orthopaedic surgeons was missing from the Children's Bureau. Although orthopaedic surgeons were appointed to an Advisory Committee on Maternal and Child Health and Crippled Children's Services, they formed a very minor representation in a huge body. Furthermore, this so-called Advisory Committee did not seem to have any particular advisory function and seemed to have little influence. The problems of the orthopaedically crippled child were little discussed, and little advice was sought. There arose the feeling that the Children's Bureau had been friendly toward orthopaedic surgery during the period when the Bureau had few friends and was insecure, but that, once it had come of age, it forgot its friends of earlier years. It is entirely likely that orthopaedic surgeons were too sensitive about this relationship, but this feeling did exist.

More recently, there is again evidence of a closer liaison between the Children's Bureau and orthopaedic surgery. The Joint Committee on the Public Care of Crippled Children, which is composed of representatives of The American Orthopaedic Association, The American Academy of Orthopaedic Surgeons, and the Section on Orthopaedic Surgery of the American Medical Association, has for some time indicated to the Bureau that it was available as an advisory body in the problems of the crippled child and orthopaedic surgery. On April 24, 1950, after a meeting of representatives of the Children's Bureau and representatives of this Committee, the Joint Committee on the Public Care of Crippled Children was appointed as a Technical Advisory Group on Orthopaedic Surgery to the Children's Bureau. Since that time, the Joint Committee has met with representatives of the Children's Bureau from time to time and has made certain recommendations regarding crippled children's services. It is our hope that this relationship may be fostered and further developed. The Committee, as a representative of orthopaedic surgery, stands ready to confer, to consult, and to advise, and indeed stands ready to listen. It insists, however, that orthopaedic surgery should participate in the decisions affecting the crippled child and orthopaedic surgery.

We, in orthopaedic surgery, appreciate the beneficial influence that the Crippled Children's Program, fostered by the Children's Bureau, has had upon the care of the crippled child in the United States. The program has assisted directly in the care of the individual child. It has stimulated and fostered the development of programs in various States. Furthermore, by establishing that certain standards be met before Federal funds were made available, the Bureau has incited a better quality of care of the crippled child. It is well to recall, however, that in many States satisfactory programs for the care of crippled children existed prior to the Federal act of 1935. Many voluntary agencies were doing an excellent job and have continued to do so. In all areas, State Crippled Children's Programs fostered by the Federal Government have strengthened the care of the crippled child.

Furthermore, in supporting the program in the various states, the Children's Bureau has given the individual States considerable freedom in their programs. This is creditable. It is difficult to provide rules which are applicable to all States. On occasions, certain of the practices which the Children's Bureau have recommended have been criticized, yet it must always be considered that its rules are general and that, although they may be worthy of criticism as applied to one area, they may be highly desirable in another. On occasion, it seems that recommendations are prescribed by the Children's Bureau which require needlessly expensive and elaborate programs and details of care which are economically unsound and unfeasible in a particular area. Whatever the criticisms, the Crippled Children's Program, it must be admitted, is playing a large role in the care of the crippled child in the United States. Where it goes in the future, and which road it will follow, will depend upon many factors which guide the future of medical practice generally. There are some considerations which we might discuss now.

The purpose of the Crippled Children's Program might be defined in the simplest form as that of aiding and supporting the care of crippled children in all the States and, in so far as possible, seeing that the needed care is provided. At the same time, its purpose should be to improve the standards of care, not only for the children directly concerned in the program but also the standards of care for all of our children, whether in the program or not. Let us analyze the significance of these two purposes.

If we are to improve the standards of care for all of our children, prime consideration must be given to the training of orthopaedic surgeons of the future and to teaching programs generally. It seems essential, therefore, that the Children's Bureau in distributing funds should indicate that priority in the use of these funds for the care of the crippled child should be given to provide adequate support to those facilities which are concerned with teaching programs. In such an order of preference should be the support of hospitalization of patients of the program, first, in those hospitals which have undergraduate and graduate teaching in the form of approved orthopaedic residency programs; and, second, in those hospitals which have approved orthopaedic residency programs without undergraduate teaching. In this present period, in which insurance programs are playing an increasing role in the economy of medicine, the teaching ward services are being depleted of patients. The children of these services are valuable for undergraduate teaching and almost invaluable for resident training. It is most important in the training of orthopaedic surgeons of the future in the care of crippled children that their teaching services be supported to a preferential degree in the hospitalization of the children of the Crippled Children's Program.

Another major consideration is that the distribution of funds should be guided by the principle that they be used to strengthen the facilities for the care of crippled children, whether the child is in the Crippled Children's Program or not. In our opinion, we will not aid in the problem of the crippled child to the fullest if a large part of this financial support is directed to those hospitals which are concerned with treating cases of this group only. If, for example, children in the Crippled Children's Program are treated in isolated state hospitals whose activities are concerned solely with the care of children whose economic support needs to be provided, these children alone will receive the benefit of the Federal support. On the other hand, if the children in the Crippled Children's Program are supported in their hospitalization in hospital units which take care of the crippled child whatever his economic status, these funds will tend to develop and to maintain facilities for the care of patients which will be generally available to all crippled children of whatever status. This would provide not only physical facilities but also personnel who would be available for the care of crippled children whatever their financial state. It will preserve and improve the facilities which are available to your child and mine. This principle becomes of increasing importance as a larger proportion of children come under the care of such services. It would seem wise, therefore, in the distribution of Federal funds to the States in support of the Crippled Children's Program, that preference be indicated for adequate support to hospitals in which activities are not solely confined to the care of patients in the Crippled Children's Program and children who receive free medical care. If we interpret this rather directly, it would seem undesirable as a general principle for the funds from the Children's Bureau to be directed primarily toward supporting hospitalization of children in state institutions the total functions and activities of which are confined to the care of these children and other children whose medical care is completely supported by public funds. On the other hand, I hastily add that, if a state hospital is a part of a teaching unit and fulfills all the other tenets we have mentioned, it should participate in the program along with other hospitals that fulfill the same tenets.

Other comments that we would ordinarily make regarding Crippled Children's Services were covered in the fourteen points of recommendation by the Joint Committee on the Public Care of Crippled Children to the Children's Bureau in 1952. These were alluded to by Dr. Shands in his recent discussion of the crippled child before this Association at the combined meeting in Great Britain in 1952.

We would like to mention certain other things. We feel that a means test should be used as one of the cards of admission to the crippled children's services. It is true that an orthopaedic crippling disease of long duration may be an insurmountable economic burden for a family that can support its ordinary medical care for acute illness. This must be considered when the yardstick of financial responsibility for a family is employed. Related to this is our personal conviction that we in orthopaedic surgery should provide care for these children of the Crippled Children's Program on the basis that it is in part a charitable enterprise on our part. As long as the plan of medical practice is such as it is today, we would favor payments to orthopaedic surgeons for the care of these children which should be so low that the surgeon would not be led to compete for the care of the children on the basis of financial remuneration. We believe that there is some advantage to paying quite an adequate fee for the out-patient clinics themselves and little or no fee for the surgery. This would produce one other desirable influence in that it would favor the distribution of these children in teaching institutions which have resident training programs in orthopaedic surgery. I would like to add that if, in the changing pattern of medical practice, different economic factors arise both in the care of these children and in the care of other patients as well, the remuneration should be such as to pay the surgeon adequately for his services.

We would like to encourage the Children's Bureau to aid as it can all research appropriate to the problems of the crippled child and to aid new projects that will develop better care and knowledge in this field.

We would be remiss if we did not emphasize that orthopaedic crippling disabilities in the aggregate require longer hospitalization and more expensive medical care over the years than do most other forms of crippling disease. We trust that the Children's Bureau will always bear this in mind.

Orthopaedic surgery has many responsibilities in this area. We, in orthopaedic surgery, must work actively to improve the crippled children's programs at the State and local levels. We cannot content ourselves that we have done our duty merely by taking care of the individual child. We must lend our influence to improve the programs at an organizational level and must participate in the total breadth of the rehabilitation of the crippled child. We should be and are prepared to do all we can to improve the crippled children's programs. However, we would like to participate in the prospective programs and activities at a planning level. We are prepared to listen, but we are also prepared to consult and advise.

COOPERATION AND COORDINATION OF AGENCIES ENGAGED IN THE CARE OF CRIPPLED CHILDREN AND THE IMPORTANCE OF THE CHARITABLE ORGANIZATIONS

BY A. BRUCE GILL, M.D., WYNNEWOOD, PENNSYLVANIA

We have just listened to representatives of Federal and State Bureaus which are occupied in their respective fields of supervision with the public care of crippled children. Nothing thus far has been said of the many private charitable institutions, societies, and organizations, manned in large part by volunteer workers, which have been and still are the most basic and important factor in this work.

All reforms and all movements for the improvement of the human race, physical and spiritual, begin in the minds and the hearts of a few individuals. They may arise independently in more than one locality and in more than one country. These ideals grow and spread slowly because of the vast passive indifference of the people or because of the active enmity of objectors. Eventually, however, the movement gains force and momentum. Primary separate groups of people become coordinated and amalgamated into larger and larger groups and societies. The movement may at last become a national urge and a national policy; but always, if the reform is to be permanent, if the improved order is to survive, it must remain imbedded in the hearts of the people and must continue to find expression in their lives. Governments and their processes cannot maintain an ideal that is not cherished and practised by the people.

The history of the care of crippled children in this country and in other countries has, in general, pursued some such course. Less than one hundred years ago, a few orthopaedic hospitals were established in this country, and for many years the surgical care of the crippled child was largely centered in these institutions. In more recent years, this work has grown rapidly. Charitable societies and organizations, the sole or chief purpose of which is to promote the welfare of crippled children, sprang into existence all over the country; and great organizations like the Shriners, the International Rotary, Lions, Kiwanis, and Elks Clubs, the International Society for Crippled Children, numerous orthopaedic hospitals and clinics, public and private schools, and eventually The National Foundation for Infantile Paralysis reached into all parts of the land and sought out and cared for the crippled child. In still more recent years, there was founded the Alfred I. duPont Institute of the Nemours Foundation, the vast potentialities of which for good can at this time scarcely be conceived.

The point I wish to emphasize strongly is that this vast work was begun and was carried on for many years by charitable individuals and societies and organizations before State and Federal agencies were established to assist with it but not to dominate it. It is true that a few States have for many years made contributions to this purpose or have inaugurated a State plan for the care of crippled children. About twenty years ago, the Federal Government began to allot comparatively small funds to the various States, and particularly to those States which were considered to be too poor to provide for the needs of their own crippled children.

The work has been enlarged to include not only orthopaedic care, but also special physical, academic, and vocational education and job-placement,—all leading to the end of making the crippled person economically independent. This requires the cooperation of many other agencies not hitherto mentioned—such as State Boards of Education, Rehabilitation, and Labor and sympathetic labor unions and industry—to give work to the physically handicapped. Nor should we overlook the enormous growth of medical science and its application to the prevention and cure of crippling diseases and conditions.

Thus, during the tremendous growth of the movement for the care of the handicapped child during the past fifty years, agencies to promote this purpose have multiplied beyond the dreams of the early workers in this field. I believe that it is but an expression of the outstanding characteristics of the American people,—their innate generosity, their desire and eagerness to help the poor, the weak, and the handicapped, and their great sense of fair play for individuals and minority groups and nations.

What appears to be needed now is not duplication of work by new or more agencies, but an efficient cooperation and coordination of all from the Federal Government down to the small local groups or societies. I shall mention a number of principles which should guide in accomplishing and establishing such a condition:

Cooperation must be voluntary, not compulsory.

Nothing should be done to destroy or to take away the interest and the devotion of the individual and the small groups. They must not be deprived of initiative or of opportunities to carry on their local work. They must not be overbossed, over regulated, or regimented. Their urge to carry on this work for humanity is a spontaneous thing which wells up out of their goodness of heart. It is their obligation and their pleasure. It has been built into their character. We welcome State and Federal assistance for the care and training of crippled children when this cannot be well accomplished without their aid. We vigorously oppose State or Federal control and management.

For example, for almost twenty-five years the crippled children (and many adults as well) in four counties in Pennsylvania were cared for by the County Societies for Crippled Children. I can vouch for the thoroughness and efficiency of this work, during bad times as well as good. When a time came that the State agent attempted to usurp management and control of these clinics, the officers of the local societies told the representatives of the State agency, in no uncertain terms, that they had been caring for their own crippled children for many years and that they proposed to continue to do so whether or not the State should withhold financial assistance. A few years later, when State funds were not available for the hospitalization of crippled children, these societies continued to provide complete care, as they had always done.

The people in any community know their own needs much better than any outside agency can know them. They have a personal interest in their handicapped children because they know them and their families.

Expense of organization and administration is low. Volunteer workers do much of the work. For example, there is one man who for twenty-eight years has organized and managed the work in one county during his leisure time. On clinic days he spends the entire day at the clinic. He spends many hours in visiting children and their families and in transporting them to and from more than twenty hospitals and institutions, some of them as far away as Philadelphia, Wilmington, and Atlantic City, where the children have been treated during varying periods of time.

Charitable work done on the local level avoids political and idealogical complications. Yet, certain problems are beyond the ability of the community to handle, such as hospitalization of patients with tuberculosis of bones and joints. The State should give assistance.

Advisory boards to the State agency should include representative orthopaedic surgeons, pediatricians, officers of the State Society for Crippled Children, and heads or representatives of the State Departments of Health, Public Welfare, Education, Rehabilitation and Labor.

Conferences should be arranged among local groups where more than one exists in order to avoid duplication of activities and to consider new problems that may arise.

Research studies of the best means to be employed for the coordination of activities for the physical care, education, occupational training, and for the placement of crippled children should be carried out. Such studies might be made by the State advisory boards to meet the conditions within the particular State. A national study by the Children's Bureau of the Federal Government should be very valuable. The Nemours Foundation has made a beginning in acting in an advisory capacity to bring about coordination of efforts by numerous existing agencies in several States and has underwritten certain expenses. The results have been very strikingly satisfactory.

DR. SHANDS: We are very fortunate in having with us three orthopaedic surgeons from overseas who are to present some of the aspects of their Crippled Children's Programs.

The first one of these speakers, I feel deeply indebted to, because, in 1937, I had the pleasure of visiting the Princess Margaret Rose Crippled Children's Hospital in Edinburgh, of which he is Chief Surgeon, and I obtained many ideas for the building of our institution. I also had the pleasure, in 1951, of visiting this institution again and in addition visiting the Trefoil School for Crippled Children in Edinburgh of which he is also the Chief Surgeon. Mr. Mercer is the Professor of Orthopaedic Surgery at the University of Edinburgh and is extremely well known by all of us for his writings. Mr. Mercer, will you tell us about what goes on in Scotland?

THE CARE OF THE CRIPPLED CHILD IN SCOTLAND

BY PROF. WALTER MERCER, EDINBURGH, SCOTLAND

The National Health Service in my country has divided Scotland into five regions, and the one that I shall talk about is the Southeastern Region, with its main hospital in Edinburgh as a center. This includes eight counties with a population of about one million.

The main children's hospital is the Princess Margaret Rose Hospital in Edinburgh. This is closely allied to the Royal Infirmary where the orthopaedic departments for adults are located. There are also five outlying general hospitals in which there are orthopaedic beds.

The care of crippled children is carried out with two objectives:

1. The treatment of children already crippled and their rehabilitation; their training for productive work; or, if this is impossible, their accommodation in sheltered workshops or in their own homes;
2. The pursuit of all measures of a preventive nature that will minimize the number of children who may be crippled in the future.

To carry out these two objectives, an orthopaedic scheme has been set up to cover as well as possible the whole area. The scheme is based on the well recognized axiom that to be effective, especially in the field of prevention, the orthopaedic surgeon must go to the patient in the peripheral areas; if he waits for the patient to be brought to him in the central hospital, time and hope of success of treatment will be lost.

The scheme embodies, therefore, a central orthopaedic hospital with a network of associated major and minor clinics covering the whole area. These clinics are staffed by orthopaedic surgeons and physical therapists, and they are visited regularly by the medical staff of the parent central hospital.

Central Orthopaedic Hospital

The whole organization of our scheme is built around our Central Orthopaedic Hospital, the Princess Margaret Rose Hospital, which is in close relationship with the University of Edinburgh and the University Medical School but which has its own individual board of management.

This Hospital has the usual number of special characteristics:

1. Wards designed for treatment in open air and sunshine;
2. Operating theaters with every possible means of promoting asepsis;
3. Plaster rooms with special equipment;
4. First-class roentgenographic and photographic apparatus;
5. Physical-therapy equipment with treatment baths and a large pool for poliomyelitic patients;
6. Occupational therapy classes;

7. Schoolteachers for the education of children of school age (the children are grouped suitably by ages and wards);

8. Almoners;

9. Workshops equipped and staffed for the quick manufacture and exact fitting of splints and for research in new designs and new materials.

The Hospital is also helpful in providing facilities for the training and employment of adolescent cripples. Boy Scouts, Cub Scouts, Girl Guides, and Brownies have organized groups among the patients and do a lot by their work toward fostering a spirit of self-reliance and determination to overcome handicaps. The Hospital, therefore, provides not only surgical and nursing requirements, but also many ancillary services.

The importance of education is recognized. The children are admitted from pre-school age to the age of qualifying for the university. The necessity for education controls, to a certain extent, the planning of the wards, as regards age and sex.

Our Hospital is a very happy Hospital, and, as one approaches it, one becomes aware of the presence of happiness by eye and by ear—an attractive sight and a most cheerful sound. The wards are open completely at one end to sun and wind; although the former is in short supply in Scotland, the latter is rarely absent.

We believe that it is a great advantage for this Hospital to be near the University with its good General Hospital. The Staffs of both Hospitals do cooperate, to the advantages of the service.

Teamwork is developed in the associated Staff, and any specialist is readily available for the care of these little children. Classes of medical students attend the Hospital, and the students can catch this spirit and learn how mutually helpful a general hospital and an orthopaedic hospital can be. They see that an open-air country hospital for children offers special advantages which cannot be associated with a city hospital. The open-air hospital is the core of the organization and by it alone can the necessary means of treating the serious cases be provided.

The clinics cannot run effectively and happily unless they are associated with a central hospital, for patients are found who need in-patient treatment in such an institution and for whom no other treatment will avail. If these patients are not cared for, the faith and the hope of the parents will quickly decline.

In the Southeastern Region, we have six general hospitals which have:

1. An orthopaedic department, with out-patient service and with some beds for short-stay patients;

2. An accident service.

Obvious functions of the Central Orthopaedic Hospital are teaching and research, and these are the concern of the Professor of Orthopaedic Surgery of the University, who is on the Staffs of all the hospitals in the area. The Director of the Hospital and his Staff take an active part in the regional work, so that there is a continual exchange of ideas. The Junior Staff rotates, and the whole field of orthopaedic endeavor in the region is available to every member of the Staff. The Professor has time for his primary responsibility to the University, the promulgation and advancement of knowledge, time for his own work, and time to share with juniors in his own department.

The Peripheral Clinics

The majority of the Peripheral Clinics were started by the combined efforts of voluntary workers and local authority. They now come under the National Health Service, but for the most part are still administered by the local authorities, who provide accommodation for the major clinics and secretarial assistance.

1. *Major Clinics*

Major clinics in the smaller towns are usually held in a specially equipped gymnasium. A physical therapist with orthopaedic training, that is, with some experience of orthopaedic nursing and a knowledge of plaster work and minor repairs to appliances, usually resides in one of these small towns and looks after the patients at that clinic and at the other clinics in the neighborhood.

To these major clinics the surgeons from the Central Hospital come approximately once a month; for that visit, children from the local minor clinics are brought in.

Some of the major clinics are held in the out-patient department of a general hospital, but a certain number of *ad hoc* orthopaedic clinics are necessary in the smaller towns, in order to bring a means of special diagnosis, treatment, and after-care within the easy reach of patients, particularly children, in every part of the Region.

It is sometimes difficult for a general practitioner to persuade a mother when she first notices that her child is limping or holding himself badly that she should at once take him on the long journey to a distant orthopaedic hospital. She will, however, quite readily take her child to the local market town. Quickly, the whole population becomes aware that the orthopaedic clinic is a place where gentle handling and expert care are available when anything goes wrong with a child's limbs or spine.

The great majority of children can be treated almost entirely as out-patients. A clinic within reasonable reach of the patient's home makes this possible.

When it is also remembered that this treatment means only periodic attendance at the clinic, and that the treatment does not interfere with the patient's schooling but, on the other hand, enables many children to attend school who could not otherwise do so, the advantages and the economy of this system stand out very clearly. This is appreciated by the education and health authorities.

In the County of Fife, with a total population of 312,000, there are nine major and eight minor clinics. All seventeen are visited at least twice weekly for a half-day or more by a physical therapist who carries out the necessary treatment and supervision. The consultant visits the major clinics at monthly intervals and sees approximately forty patients at a time. At the consultant's visit, a nurse, an almoner, a physical therapist, and the parents are usually present, and often the family doctor and the school doctor as well.

2. *Minor Clinics*

Minor clinics are situated in the smaller villages and are usually held in a temporary accommodation, such as a room in a school, a church hall, or the like, on usually one or two afternoons a week. Here too, the patient loses no time from school. If there is a large number of children at one school who can be cared for in classes, for instance, in foot classes, a physical therapist frequently holds a class in that school instead of at the clinic, in order to save school time.

In certain cases, the children may be home-bound. They are then treated by the physical therapist at their own homes, for in each county the physical therapist has a car and goes around and sees patients in this way.

Twenty or twenty-five years ago in this area, one frequently saw a patient with congenital club-foot for the first time at the age of six. The mother had waited, she said, until the child "was stronger" and able to withstand the treatment! Now patients are brought along, and the condition is discovered right away. Very often, we see a child at the clinic before the mother is out of the maternity hospital.

In this way, we are able to deal with all those cases that need early treatment. When a case of club-foot is discovered at the peripheral clinic, a physical therapist starts her treatment, the surgeon on his visit confirms the right treatment, and manipulation and splinting can be carried on at home. Thus, the child remains at home—the best place for him.

By the establishment of the major and minor clinics, it is also possible to get children who have been operated upon out of the Central Hospital fairly quickly, as it is known that they will continue to receive the treatment and supervision in their localities and that they will be under constant observation, possibly for years, by the visiting surgeon.

In addition, most of the preventive work in static cases is done in these clinics. At least 60 per cent. of the patients can be successfully treated without going to a hospital. Therefore, the children have the advantage of getting satisfactory treatment while still living at home and still carrying on at school with their fellows.

Discovery and Admission of Patients

The children are referred to the peripheral clinic through a variety of sources—by the local practitioner or family doctor, from welfare clinics for pre-school children, by school medical officers, by midwives and schoolteachers, and, as the knowledge of what can be done becomes known, by the force of public opinion.

As regards handicapped children found in maternity hospitals, the arrangement is that the obstetrician notifies the office of the county medical officer. A physical therapist is then sent to the hospital, and such treatment as is deemed necessary and practicable is carried out. After the infant leaves the hospital, he is taken to the orthopaedic clinic where he is seen by an orthopaedic surgeon.

The Central Hospital and the clinics are in touch with other services, such as child-guidance clinics, speech therapy clinics, and spastic clinics, so that children requiring special investigation can be examined without delay.

Health visiting nurses are in constant touch with families in their homes and any handicapped child who happens to have escaped the net of supervision of parents, school medical officers, and others, is detected by these visitors and is referred to the clinic, either through a doctor or directly.

From my experience of the working of the scheme, I can say that there is little chance of a child entering school with a deformity for which he has not already been referred to an orthopaedic clinic and no chance of a child with a disability leaving school without having been examined by an orthopaedic surgeon.

To get some idea of numbers, these figures may be given in referring to one area of Scotland. In our Central Hospital, we take children up to the age of sixteen, and there are 170 beds.

In the associated major and minor clinics, numbering eighty, there are 8,000 children under supervision and treatment. There are, of course, beds in some of the peripheral hospitals for children, in addition to the 170 in the Central Hospital.

Training for Employment

At the moment, there are few settlements for training badly crippled children. There is one in our Region where girls can be taught sewing, bookkeeping, and the like, and there are several in England which take a certain number of patients from outside the country, where watchmaking, boot-repairing, and the like are taught. With the provision of more light industries and with the cooperation of employers, more and more cripples are being taken in to be actually trained in factories and offices.

In placing older children in employment, the almoner's efforts are often successful, augmented by those of the Disablement Resettlement Officer appointed by the Ministry of Labour.

Cripples' Aid Societies and Voluntary Bodies

Under the Health Act, theoretically, local authorities are permitted, or are obliged, to provide practically all services for the cripple, but they do not, in practice, do so in many areas, probably largely because of the lack of money. Voluntary bodies which have been in existence in some cases for a hundred years do a great deal to fill in the gap. Many of them run some form of sheltered workshop and hostel for a large mass of members. Some of them run ancillary homes of a semiconvalescent nature, and all work in the closest cooperation with the orthopaedic scheme. Under the Assistance Act, local authorities can employ those registered voluntary bodies as agents for employment purposes. This permits an expansion of an already existing good service to take place. The scheme in time will, I think, be completely adequate, but there are gaps in it now, due principally to lack of money. I foresee the time, however, when all potential or actual cripples will be found and efficiently treated.

DR. SHANDS: Now we will hear from Mr. S. Alan S. Malkin of Nottingham about some of the problems in England.

As many of you will remember, Mr. Malkin was with us as President of The British Orthopaedic Association when we met in Quebec in 1948.

The Care of the Crippled Child in England

BY S. A. S. MALKIN, NOTTINGHAM, ENGLAND

I am sure we have listened with the very greatest interest to this discussion of the problems which we all have to face. So many of them are common both to this country and to Great Britain. It is of the greatest importance that we should get together and help one another to solve them.

When I first went to Nottingham, more than thirty years ago, to organize a scheme for the prevention of crippling conditions and the treatment and training of cripples, I remember talking over the matter with Sir Robert Jones. He was most anxious that the scheme should not be merely for crippled children. He felt that the real problem was with disabled people and that one should not confine one's activities to children, who, after all, as time goes on, become adults and still sometimes require care; nor should people who become disabled by accident or disease when they are adults be excluded. So, today, in the remarks that I shall make, I shall refer not only to crippled children, but also to the disabled in general.

In England, for the treatment of crippled children, we have an organization similar to that in Scotland, about which Prof. Mercer has spoken to you. Organizations on similar lines exist throughout Great Britain and in Northern Ireland. I think, as Prof. Mercer has said, that they work extremely well and ensure that every child can be seen by an orthopaedic surgeon.

Some of us are not quite happy about certain aspects of the work. For example, we are not sure what is the best treatment for cerebral palsy. Should children suffering from this condition be segregated? Should they be treated as out-patients? Should they be in special hospitals? Should there be special schools for them? I do not know the complete answers, but, at least, I can say that in Great Britain there is a great increase in public interest in these children. I hope that soon satisfactory answers to these questions will be found.

We are anxious that the best should be done for children suffering from the effects of infantile paralysis and that the orthopaedic surgeon should be in the picture at the very earliest moment, while the child is still in the infectious stage and before he has reached the stage of being accepted at an orthopaedic hospital. This is because we feel strongly that orthopaedic surgeons should be in a position to help in the prevention of deformities and in the early treatment and assessment. We are also concerned in ensuring that, when a child does leave the hospital for infectious diseases, he should go to a center where there are full facilities for giving him the best possible treatment.

As you probably know, as a result of the creation of the National Health Service, there have been established a greatly increased number of consulting centers throughout Great Britain. Our concern is that the children who are in outlying districts should not stay there but should, in spite of the problems of distance and of visiting by their parents (which has been referred to today), be brought together in orthopaedic centers where they can be treated by the best available methods.

On the other hand, we are not quite sure that some of our methods used in the treatment of poliomyelitis are the best. The Medical Research Council has recently set up a working party under the chairmanship of Prof. Seddon, whom most of you know, to investigate certain aspects of this problem. A few centers have been selected in Great Britain where research and treatment are to be carried out. I think that this will probably lead to some very good and useful work.

In Great Britain, we are not troubled in the same way as perhaps some of you may be about the actual availability of treatment, because under the National Health Service, to which all contribute, all are entitled to the treatment they need. It is fair to say that crippled children receive, through the National Health Service, most of the things which they require. They receive treatment and they are supplied with appliances, and when needed, artificial limbs.

The problem of crippled children's services may be more one of providing education than of providing treatment. For those who cannot travel daily to school, special schools have been established,—some on a voluntary basis but supported by the Ministry of Education. North of Nottingham, there is one such school, which is under the control of the Central Council for the Care of Cripples. To this school, disabled children go; grants are made by the education authorities to pay for their maintenance and education. The organization of this school, I am sure Dr. Gill will be pleased to hear, is in non-governmental hands and the control of it is completely non-governmental. It is true, of course, that a certain amount of inspection takes place, but we have found great cooperation and, I think, little if any difficulty in that respect.

When the disabled children leave school, the education authorities are able to provide training to prepare them for work at which they can earn their living. Certain schools have been established for this purpose.

There have, as you know, been great developments in the rehabilitation services connected with hospitals. At Harlow Wood Orthopaedic Hospital, Nottingham, as an example, we have a rehabilitation unit similar to the rehabilitation units which were developed for service men during the War. To this unit, men go for the final stages of treatment, so that when they leave the hospital, they should be able to return to their work without delay, that is, without the need for a long period of light work.

In addition to this, the Ministry of Labour was empowered, in 1944, to provide what are known as Industrial Rehabilitation Units. These are units to which patients can go after the final stages of hospital treatment have been completed. They go for two purposes:

1. To enable them to get back into the industrial atmosphere and to give them an opportunity to do, under easier conditions, the skilled work which they will have to do when they go back to their jobs;

2. To see, if men are unfit to return to their pre-accident work, for what type of work they can be trained. From these units, if necessary, patients can be drafted to training colleges, which in themselves, constitute advanced rehabilitation units.

I have been very interested in helping to develop the Portland Training College for the disabled, which has been built next to Harlow Wood Orthopaedic Hospital where I work. This is a voluntary undertaking built with money voluntarily given; it works in close collaboration with the Ministry of Labour which provides funds for the costs of maintenance. Men can be sent there as soon as their hospital treatment has been completed, or they may go, as I have already mentioned, by way of an industrial rehabilitation unit.

There are also some sheltered workshops for people who are unable to take their places in the ordinary labor market. These are controlled by an official company called "Remploy", and are intended to provide remunerative work for very disabled people.

There is a great feeling in Great Britain, that, even if a person is disabled, he still has some contribution to make to the life of the community and to his own upkeep. Even if a man is able to do only 50 per cent. of a normal man's work, it is far better for him to do that 50 per cent. than it is for us to say that, since he is unfit, he must be left alone. Most people in Great Britain who think about the problem feel that it is in the country's interest for all to do what they are capable of doing. It is obviously preferable, from every point of view, to train the disabled to support themselves rather than to maintain them out of public funds. All this, however, involves a great deal of organization, and there can be a great deal of overlapping.

In 1951, the Ministry of Health issued a circular which gave the local authorities power to do certain things for disabled people. Essentially, the plan was to enable the disabled to assist themselves to overcome the effects of their disabilities. The local authorities can give advice and guidance to handicapped persons on personal problems; they can encourage them to take part in the activities of social clubs; and they can endeavor to arrange for voluntary workers to visit the severely disabled, if it is needed.

This power given to the local authorities is permissive and some, though not all, authorities have availed themselves of this opportunity to help the disabled. It was interesting that the circular specifically referred to the use of voluntary organizations for carrying out its provisions. This was probably done because it was felt that for local authorities to carry out all these provisions would be a most expensive matter and it was important to have the help of voluntary spirit and voluntary effort.

So, in Nottingham and in other centers, were set up what are called Local Voluntary Associations to care for the welfare of the physically handicapped. These associations are representative of the local authorities and of all voluntary bodies concerned with the disabled. The objectives of these associations are to make and to maintain a record of the physically handicapped, to investigate the need for assistance, to act as coordinating bodies for all organizations interested in the welfare of the physically handicapped in the area, to cooperate with the appropriate bodies in working for the welfare of the physically handicapped, to appoint local committees or representatives wherever required, and to undertake such things as may be conducive to the welfare of the physically handicapped in the area under their control. The main objectives are, therefore, to see that the work is done and to prevent overlapping.

The Nottingham Association includes representatives of the Red Cross, women's organizations, and many others who are interested in the care and welfare of the crippled. The Association is acting as an agent for the Nottinghamshire County Council. I believe that the work it will do and the efficiency with which it will do it will mean a great deal to the disabled people in the County. Throughout the work for the rehabilitation of the disabled in Great Britain, it has become the accepted plan that there should be cooperation between Government Departments, local authorities, and voluntary bodies,—the Government and local authorities, in the main, providing resources and some direction and the voluntary bodies providing occasionally capital and always the voluntary spirit and enthusiasm which are vital in any undertaking.

I have been most interested in all I have heard from other speakers. I feel that this Symposium will prove of great benefit to us all. Points have been brought forward which some of us have not thought of previously. There is no doubt that, to make our work as orthopaedic surgeons really effective, we must think of our patients not as orthopaedic problems only, but as personal problems. We must not rest content until (however successful the treatment we have carried out may be) the patient has returned to his place in the community as an active and effective worker. This is a platitude, but it is worth repeating. It is really a re-statement of a first principle—a principle which was the guide of that great orthopaedic surgeon, Sir Robert Jones, who meant and still means so much to many of us on both sides of the Atlantic. I realize that what I have given is a bare outline of the position in Great Britain, but I do appreciate very much the opportunity to take part in this discussion.

DR. SHANDS: Thank you very much, Mr. Malkin. I certainly wish you the greatest of success in your coordinating agency which I feel is one of the most important activities that has been brought out in this Symposium.

Now, the next distinguished speaker on the program is from Greece: from Athens. Last year he was made a Corresponding Member of our Association. We will hear from Dr. Garofalides of Athens.

Crippled Children's Services in Greece

BY THEODORE GAROFALIDES, M.D., ATHENS, GREECE

The Hellenic Society for Crippled Children began to take shape in 1948, through the tireless efforts of the lady members of the Society and especially through the endeavors of the President of the Society, Mrs. N. Mikroulakis.

The Hellenic Society for Crippled Children was founded in 1937 through the combined aid of the Near East Foundation and the Greek Rotary Club. From 1937 to 1947, the Society's activities were carried out with the cooperation of the Near East Foundation, which helped the Society financially.

The function of our Society is to provide for:

1. The medical supervision of crippled children by orthopaedists, pediatricians, and other specialists.

2. The treatment, in our medical center, of crippled children by means of physical therapy, massage, and electrotherapy carried out by personnel who were trained and supervised in every respect by the English physical therapist, Miss Collier. At present, the work is performed by six women well trained in the principles of physical therapy and by two physical instructors. In the summer, the children of the center, as well as other children, go to a special camp where they take part in outdoor activities for the improvement of their health.

3. The hospitalization of children who are in need of surgery in special hospitals in Athens.

4. The manufacture and fitting of prostheses and braces in a shop owned and operated by the Society.

Through generous contributions, financial and otherwise, the Near East Foundation and the American Mission for Aid to Greece have sent us electric machines and tools for our brace shop, which is the only one in Greece for the manufacture of children's appliances.

Please bear in mind that our rehabilitation center and shop are very poor in appearance and are not spacious, but we try to achieve the best possible results with whatever means we possess. By visiting your wonderful country every year, we try to transplant to our organization your methods.

Despite our difficulties and our economic burdens, our Society is expanding its work in the rehabilitation of crippled children: The number of crippled children who reported to our Society in 1949 was 988; in 1950, 1,675; in 1951, 2,489; in 1952, 2,281; and for the year 1953, 2,334. This increase in the number of patients cared for shows the activity and usefulness of the Hellenic Society for Crippled Children, as well as the confidence of the disabled in the work done by the Society. There is also considerable activity in the social rehabilitation of the children. Many of them are placed with private families in Athens for the duration of their treatment; and while they are with these families, they are under the supervision of two of our visiting nurses.

In conclusion, I wish to thank you for having elected me member of your honored Association and I am particularly proud as it is the first time that Greece has been represented in your Association. I hope that this will inaugurate a lasting medical relationship and contact between your great country and my own.

EDITORIALS

THE ORTHOPAEDIC RESEARCH SOCIETY

The First Annual Meeting of The Orthopaedic Research Society will be held in Los Angeles, California, on the Saturday preceding the opening of the Annual Meeting of The American Academy of Orthopaedic Surgeons. The program calls for a morning scientific session, and a business meeting in the afternoon at which the Constitution and By-Laws will be adopted and a permanent organization completed. This meeting will mark the realization of the hopes of its founders for the establishment of a society dedicated wholly to the promotion of orthopaedic research, and membership is open to any qualified physician or other scientific worker engaged in worth-while investigation in this field.

In addition to the usual officers and membership and other committees, the Constitution provides for an Advisory Council composed of five Senior Members serving for terms of five years. It will be the duty of this Council to pass upon the merits of various research projects submitted to it and to advise investigators as to ways and means of achieving their objectives. Youth is considered important in the organization and this is emphasized by the provision in the Constitution that all members reaching the age of fifty shall be retired to the rank of Senior Members. On the other hand there is no requirement concerning the age of applicants for membership, and it is hoped that many men will be able to qualify before completing their orthopaedic training.

The purpose of the Society is to encourage research among young men entering the specialty of orthopaedic surgery, and it is hoped to accomplish this by providing a forum where men may present reports of work in progress and a meeting ground where they may exchange ideas and benefit from learning of methods and techniques that have proved helpful in the hands of others. It is hoped that men who are working on similar projects will be able to get together and to share experiences for the benefit of all. The Society will not have funds for the support of research projects, but it is hoped that the endorsement of a project by the Society or by its Advisory Council will be helpful to the worker in obtaining financial assistance from foundations or public sources.

The thoughts that lay behind the organization of this Society were several. First was the feeling that orthopaedic research has lagged, in spite of the tremendous increase in the number of men entering the orthopaedic specialty. This idea had been suggested by an analysis which showed that too few reports of research were being published. Reports had been heard of difficulties encountered by the Program Committees of the national orthopaedic organizations in getting together programs containing a high enough proportion of papers of a fundamental scientific nature for the various meetings. There is no doubt that the men who are entering upon their orthopaedic training have had previous education of the finest quality and are of the highest ability. These men did excellent work during their periods of residency training, were required to study extensively, and frequently wrote papers of high order for presentation among their colleagues. It was felt that perhaps the failure of some of these men to continue with research after entering practice is in part due to lack of encouragement and fear that whatever they undertake will not be worth while and partly due to lack of counsel and advice. Yet these men in their first years of practice have more time for research than they will have ever again in their lives. It seemed that a society devoted entirely to research, to which they would be eligible for membership, might provide an answer to their problem. Fellowship with other young men in similar positions in a research society might do a great deal to counteract the feeling of discouragement and loneliness that many of these men experience. It would also serve as an inspiration for men who were still in training or in junior staff positions in teaching hospitals.

The question of how an orthopaedic research society would fit in with other existing national organizations, such as The American Academy of Orthopaedic Surgeons and The American Orthopaedic Association, was also considered. It was felt that there should be no problem here as the purpose is different and membership is not exclusive in any of these societies. It was also thought that the programs would not be competitive, since most of the reports before the Research Society would be of work in progress and later, when the work had been completed, these might properly provide material for the general programs of the other societies.

Plans for an orthopaedic research society first began to be discussed among some of the founding members in 1950, and in 1951 a tentative organization was formed with Dr. Dallas B. Phemister as provisional President and Dr. Philip D. Wilson as Secretary. It was planned to hold an organizing meeting during the Annual Meeting of The American Academy of Orthopaedic Surgeons in Chicago in January 1952. The untimely death of Dr. Phemister shortly before that Meeting led to postponement of these plans, and the organizing meeting was held instead in January 1954, at a luncheon in the Palmer House, Chicago. A tentative organization was set up with Dr. Paul C. Colonna as President and Dr. Charles H. Herndon as Secretary. A Committee on Constitution and By-Laws was appointed with Dr. William T. Green of Boston as Chairman. This Committee reported to the Executive Committee during the meeting of The American Orthopaedic Association at Bretton Woods in July 1954, and the draft of the Constitution and By-Laws was approved. A number of members were elected and it was provided that those of the founders who were over-age would retire to senior membership as soon as the membership attained a certain size.

Thus another step in the organization of American Orthopaedic Surgery has been taken, and it is earnestly desired that the results will justify the hopes and labors of its founders. It is a happy coincidence that this Society should be born just at the time that the Orthopaedic Research Foundation should first see the light. These two are sister organizations seeking the same objective by different methods. They should work closely together but independently.

Each will be able to reinforce the efforts of the other in promoting more extensive and better research in the orthopaedic field.

Philip D. Wilson, M.D.

The Orthopaedic Research Foundation

It has long been recognized that one of the major responsibilities of a branch of medicine is the pursuit of research on its problems. In order to squarely face this responsibility, the members of a specialty must give both encouragement and financial assistance to its research-minded members and others interested in its investigative projects. Unfortunately, sufficient funds have not always been available to finance all worthy projects in orthopaedic surgery, particularly projects being carried on by orthopaedists themselves.

Realizing that action should be taken, The American Orthopaedic Association, through its Research Committee, in the fall of 1953, made a questionnaire survey of research being performed and desired to be performed by orthopaedic surgeons, as well as of its costs. This survey showed that there were 189 orthopaedists in 150 institutions working on 290 projects at a total expenditure of approximately $736,800. There were many investigative projects which were not being pursued by these same orthopaedic surgeons because of lack of time, personnel, and funds. The approximate amount of money needed for the deferred projects was $600,000. Undoubtedly some money is available for these investigators from the present sources of research funds, but it is not likely that over one-half million dollars could be obtained for orthopaedic research.

To meet this very real need an orthopaedic research foundation is proposed, a foundation which will collect and distribute funds for research and education in orthopaedic surgery and which will be under the direction and control of the orthopaedic surgeons.

In May 1952, the idea for an orthopaedic research foundation was presented to the Orthopaedic Committee of the National Research Council, of which Dr. Harold A. Sofield was then Chairman. This idea was approved by this Committee as well as by the Director of the National Research Council, but nothing further was done at that time.

In January 1954, following the above-mentioned survey, a plan for the organization of such a foundation was presented to the Executive Committee of The American Orthopaedic Association. This plan was approved in principle, and the formation of a joint committee was authorized with instructions to proceed with plans for the organization of such a foundation. This joint committee was composed of two representatives each from The American Academy of Orthopaedic Surgeons, The American Orthopaedic Association, and the Orthopaedic Research Society, and one from the Skeletal System Committee of the National Research Council *. Articles of Incorporation and By-Laws for The Orthopaedic Research Foundation were prepared by the joint committee and presented to the Executive Committee and the membership of The American Orthopaedic Association at its last meeting in June 1954. These were approved in principle. Following this meeting many pertinent suggestions were made for improvement of the By-Laws. With these suggestions in mind, the Articles and By-Laws were redrafted by the legal counsel in Cleveland who had drafted the original Articles of Incorporation and By-Laws for the American Urological Research Foundation, a two-year-old foundation of a sister specialty. These revised documents have now been approved in principle by the Executive Committee of the Academy and will be presented to the full membership of the Academy at an Executive Session at its 1955 Meeting. If they are approved in principle by the membership of the Academy, the joint committee will then work out the final details for the organization and operation of such a foundation and proceed with its formation.

What is being planned is a non-profit foundation for tax-exempt gifts to which every orthopaedic surgeon, patients, friends of orthopaedic surgery, medical commercial houses, and others may contribute. Its activities are to be "in the support of scientific research and education in orthopaedic surgery". The Foundation will be legally sponsored and organized by The American Academy of Orthopaedic Surgeons and The American Orthopaedic Association. Each society will have three members on the Board of Trustees who will be elected by the respective society for terms of not less than three years. There will be an Advisory Council, limited to fifty, composed of professional persons who have actively engaged in orthopaedic research, or research in allied fields, and lay persons who have manifested an unusual interest in orthopaedic research by financial contributions or otherwise. Requests for grants will be carefully screened by an especially selected committee upon which will be one trustee. Provisions have been made for the receipt of gifts for worth-while research projects specified for named institutions or named investigators. Such organizations as the National Research Council will be called on for advice on applications for grants when necessary. The main office of the Foundation will be an integral part of the present Central Office of the Academy, thus minimizing overhead expenditures.

For the success of this new major activity in orthopaedic surgery, every member of the specialty must feel that this is his Foundation and have a deep sense of responsibility

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* Joint committee for the organization of an orthopaedic research foundation includes:

For The American Orthopaedic Association, James A. Dickson, M.D., Fremont A. Chandler, M.D.;
For The American Academy of Orthopaedic Surgeons, Joseph S. Barr, M.D., Francis M. McKeever, M.D.;
For the Orthopaedic Research Society, Philip D. Wilson, M.D., Paul C. Colonna, M.D.;
For the Skeletal System Committee of the National Research Council, A. R. Shands, Jr., M.D., *Chairman.*

for its welfare. It should become the strongest force for progress and development which the specialty has ever had. Once the Foundation has become a reality, the whole-hearted support of every orthopaedist will be needed to ensure its success. Nothing short of a complete success is the earnest desire of all who have been developing this progressive, if not momentous, step for orthopaedic surgery.

A. R. Shands, Jr., M.D.

ORTHOPAEDIC RESEARCH

It is logical that the recently formed Orthopaedic Research Society and The Orthopaedic Research Foundation should have had their inception at about the same time. Each has arisen out of the need of furthering fundamental studies in orthopaedic surgery if the specialty is to keep its position in the rapidly growing science of surgery. Each organization has as its objective the promotion of basic investigation, but strives to attain its goal by different means.

For a number of years, orthopaedic surgeons have been growing increasingly conscious of the need of greater interest and achievement in basic studies. In one group, especially research-minded, ideas of how best to foster fundamental investigation in orthopaedics took shape in the form of a research society, and, largely through Dr. Wilson's efforts and those of the late Dr. Dallas B. Phemister, it was decided to establish such an organization. The organizational meeting of the Society was held last January.

While plans for the Society were being made, the same problem was being approached from a different angle by a different group. The report of the Research Committee of The American Orthopaedic Association of their survey to determine what orthopaedic research was actually being done in the United States and what additional research would be done if sufficient funds were available pointed out the need for better organization of research facilities and for more funds to implement prospective studies.

Information received from the Skeletal System Committee of the National Research Council indicated that, up to a year ago, there were on file 336 research projects relating to the musculoskeletal system, of which 205 were being conducted by Government agencies and 131 by non-government agencies. Only twenty-two of the projects listed were being conducted under the direction of an orthopaedic surgeon. A total of $5,500,000 was being spent on these projects at that time.

To meet needs so evident, the plans have been made for the establishment of The Orthopaedic Research Foundation in large part through Dr. Shands' efforts. The two organizations are thus mutually beneficial; one complements the other.

The By-Laws of the Foundation, as currently drafted, will be published in the next issue of *The Bulletin* of The American Academy of Orthopaedic Surgeons and will be voted upon in principle by the membership at the Annual Meeting of the Academy in January 1955.

The objectives of The Orthopaedic Research Society were defined in detail at the preliminary meeting: to stimulate the specialty to do more basic research, to promote the exchange of original ideas, to provide a means of keeping investigators who are interested in orthopaedic research informed of work in progress in other laboratories, thereby avoiding duplication and fostering collaboration, to study means of financial support of research, to advise young investigators regarding financial aid, and, lastly, to make available privileges of membership to young men interested in orthopaedic research even before they are eligible for membership in other societies—possibly even while they are still residents.

The provisional Constitution and By-Laws, tentatively adopted at the organizing meeting of the Society, have been somewhat modified following discussions at interim committee meetings held at Bretton Woods last June. These modifications are now in the draft form of the proposed Constitution and By-Laws which will be presented for final approval at the next Annual Meeting of the Society to be held in Los Angeles on

January 29, 1955. As drafted, the Constitution provides that membership be of two classes, Senior and Active. Senior members would be those over fifty years of age, qualified by reason of "previous scientific accomplishments and performance in orthopaedic surgery or related fields, and interest in the training and development of young orthopaedic surgeons". "Active members shall consist of orthopaedic surgeons or other investigators who have been elected to the Society on the basis of previous scientific accomplishment and continued activity in the field of research." Of special importance in the over-all plan of organization is the Advisory Council of five elected Senior Members each to serve for five years, one member retiring from the Council every year and one being elected to it. Among its functions, the Advisory Council would serve "to advise any investigator concerning problems encountered in research" and "to make recommendations to The Orthopaedic Research Foundation and similar organizations, regarding the financial support of specific research projects".

On the subject of application for membership, the proposed By-Laws read in part as follows: "Applications for membership must be sponsored and seconded by a member of the Society. It will be the duty of the Membership Committee to review the applications and to make specific recommendations to the membership. It is recognized that under some circumstances there may be applications for membership submitted to the Membership Committee with no sponsor."

"There shall be an Annual Meeting of the Society. . . . The program shall consist of a scientific session at which reports of research are presented by the members and invited guests and an executive session at which the business of the Society is transacted."

While organized efforts to develop a vigorous research program were being made by orthopaedic surgeons, the American College of Surgeons, in 1952, extended its very successful Forum on Fundamental Surgical Problems to include a section on orthopaedic surgery under the chairmanship of Dr. J. Albert Key. The Forum is conducted each year at the Annual Meeting of the College. The papers presented and the open discussions that have developed at the Forum meetings have proved to be extremely worth-while.

The Editor

ANNOUNCEMENT

The First Annual Meeting of The Orthopaedic Research Society will be held in the St. Louis and Foy Rooms, Hotel Statler, Los Angeles, on Saturday, January 29, 1955. It is planned to hold a Scientific Session in the morning and an Executive Session in the afternoon. All interested members of the medical profession are invited to attend the Scientific Session.

Proceedings

AMERICAN MEDICAL ASSOCIATION

SECTION ON ORTHOPAEDIC SURGERY

The Annual Meeting of the American Medical Association was held last June in San Francisco, California. The Section on Orthopaedic Surgery met on June 22, 23, and 24, under the chairmanship of Dr. Charles N. Pease. The following are summaries of the papers presented at the three meetings of the Section:

TUESDAY, JUNE 22

Skeletal Lesions in Coccidioidomycosis. Dr. Robert Mazet, Jr.[1], reported that coccidioidomycosis, an infection caused by the fungus *Coccidioides immitus*, is endemic in southwestern United States and in northern Mexico. The portal of entry is usually through the respiratory tract. The primary or pulmonary stage is generally a mild, self-limiting pneumonia; the disseminating or granulomatous stage occurs in only 0.2 per cent. of the cases. Dissemination is more common in males, and practically any organ or tissue may be involved. Skin manifestations, such as erythema nodosum or erythema multiforme, are seen in 20 per cent. of the patients with disseminating coccidioidomycosis; these manifestations are seen more often in females. Bone and joint involvement, the exception rather than the rule, occurs during the disseminated phase. The bone lesions seen in the roentgenograms are similar to those seen in patients with tuberculosis. They may be multiple. The diagnosis is established by the identification of the organism through examination of biopsy specimens or culture. There is associated fever, an elevated sedimentation rate, the rapid development of the lesions (within a few weeks), and positive complement-fixation and precipitation tests. The author reviewed twenty-two patients with skeletal involvement seen in a six-year period. The mortality rate is normally higher in colored patients than it is in white patients. In his series, ten of thirteen Negroes died, while only one of eight white patients died. A roentgenogram was shown; in it was seen the lesion in the fourth cervical vertebra which brought about a patient's death in twenty-eight days after the onset of symptoms. No specific treatment is known for this condition. Nystatin has shown promise experimentally in clinical trials.

The discussion by Dr. Lewis N. Cozen[2] and Dr. Paul McMaster[3] emphasized the high mortality rate (five deaths in fifteen of their patients). Two of their patients were treated by amputation and two by excisional surgery.

Diabetic Neuropathic Arthropathy of the Feet. Dr. Donald S. Miller[4] and Dr. William F. Lichtman[5] reported that, in recent years, the number of patients with diabetes mellitus manifesting neuropathic changes in the joints of the foot has far outweighed the number of patients in whom such changes are caused by syphilis. Thirty cases of diabetic neuropathic joints have been reported in the past ten years; to this number the authors add fifteen. The diabetic foot is frequently enlarged and shortened, usually painless; sometimes, however, there are areas of soft-tissue swelling, with areas of necrosis. Characteristically, the foot is flat, everted, and externally rotated. The pulse may or may not be diminished. The neurological changes usually found in other conditions causing neuropathy are absent. The roentgenographic picture of the foot is not always typically that of the neuropathic joint. The authors think that, in the presence of diabetes mellitus, a painless foot, with valgus deformity, loss of vibratory and position sense, and diminished reflexes, in which physiological trauma produces a progressive valgus deformity, with abnormal widening, flattening, and inversion, and in which there is evidence of hypertrophic or atrophic bone changes, is typical of diabetic neuropathic arthropathy. There is usually pronounced secondary anaemia which is thought to be of etiological significance and which should be corrected. Treatment is most often conservative; surgery is possible only in exceptional instances.

The Clinical Significance of the Transitional Lumbosacral Vertebra. Dr. Frank E. Stinchfield[6] and Dr. William Sinton[7] reviewed the lumbosacral vertebrae in one hundred consecutive patients who had been operated upon for back pain at the New York Orthopaedic Hospital. The operations in these patients represented, roughly, 10 per cent. of the 920 spine fusions done at the Hospital from 1942 to 1951. They attempted to evaluate the role of the transitional lumbosacral vertebra in respect to low-back pain with sciatica. In reviewing the roentgenograms, they found that it was impossible to predict whether little or much motion would be found to be present at the sacralized vertebra which was to be examined at operation. At least thirty-one patients had greater mobility at the vertebra than that expected from an examination of the roentgenograms. True sciatic radiation was seen in 58 per cent. of the patients; in 7 per cent., this was bilateral. Of the definitely herniated discs found at operation, all but one occurred at the level above the transitional vertebra. The one instance of a herniated disc at the level of the transitional vertebra was possible because of a very mobile transitional vertebra. There were fifteen patients who were subjected to exploratory procedures; in these, no herniation of the disc was found. These patients were treated by fusion, and thirteen became symptom-free. The authors explained the sciatica in the absence of a disc herniation by the hypothesis that there was an inflammatory arthritic process of the joint above the level of the transitional vertebra.

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[1] United States Veterans Hospital, Los Angeles 25, California.

[2] 2007 Wilshire Boulevard, Los Angeles 5, California.

[3] 9730 Wilshire Boulevard, Beverly Hills, California.

[4] 6 North Michigan Avenue, Chicago 2, Illinois.

[5] 6 North Michigan Avenue, Chicago 2, Illinois.

[6] 180 Fort Washington Avenue, New York 32, N. Y.

[7] 180 Fort Washington Avenue, New York 32, N. Y.

The Use of Iproniazid in the Treatment of Non-Tuberculous Bone and Joint Infections. Dr. David M. Bosworth [8], Dr. J. W. Fielding [9], Dr. Manuel Guzman Acosta [10], and Dr. L. M. Demarest [11] presented a report on twenty-one patients with non-tuberculous lesions of the skeletal system who had been treated with iproniazid over a two-year period. The bone lesions had not done well under the usual antibiotic therapy. All antibiotics had been discontinued, and treatment with iproniazid was begun. There were three children and eighteen adults. Clinical improvement in these patients was striking. They felt better, ate better, and gained weight. The wounds healed, even though the mixed infection could be cultured from most lesions until healing had occurred. Iproniazid did not destroy the organism, but it seemed to reduce its toxicity and vitality. In the seventeen patients with osteomyelitis who had been treated with iproniazid, thirteen lesions healed. Three of the unhealed lesions had drained from ten to twenty years. The dosage was four milligrams per kilogram of body weight a day, but it is believed advisable to commence the drug in some patients at three milligrams per kilogram of body weight a day until it is seen how well iproniazid is tolerated. Patients under treatment with iproniazid tolerate anaesthesia well. Dr. Bosworth and his associates think that therapy should be continued for several months after the lesions had healed. In two patients, toxic psychoses developed; in three, there was slight liver damage. Because of the greater toxicity of iproniazid, as compared with that of isoniazid, therapy with this drug should be begun under hospital supervision. When the dose has been standardized for a particular patient, administration of the drug can be safely carried out by means of frequent visits to the out-patient clinic. Dr. Bosworth and his associates feel that chemotherapy is still the best means of treatment for pyogenic infections. Iproniazid is a valuable adjunct in some resistant cases. Although it is specific against the tubercle bacillus, it is not specific against other organisms. The precise mode of its action is not known.

Metastatic Lesions Simulating Rupture of a Lumbosacral Intervertebral Disc. Dr. Richard T. Odell [12] and Dr. J. Albert Key [13], in discussing the symptomatology of the ruptured intervertebral disc, drew attention to the variation in neurological signs, symptoms, and roentgenographic findings. They were not surprised, in their large series of 1,200 operations, that they had seen nineteen patients with malignant tumors involving the bony spinal canal and causing nerve-root pressure. In twelve of these, the low-back pain and sciatica were caused by metastatic carcinoma (three from the prostate, two from the kidney, two from the cervix, one from the anus, one from the breast, one from the lung, one from the thyroid gland, and one from the vagina), while in seven patients the symptoms were caused by a primary tumor (in two, chondrosarcoma, in one a fibrosarcoma, in one a giant-cell tumor, in one Ewing's tumor, and in one an osteogenic sarcoma). They drew attention to the fact that in eleven patients nothing abnormal had been noted in the roentgenograms made when the person first came under their care, although, with hindsight and with the passage of time, subsequent roentgenograms showed bone changes. They noted that the vertebrae may be extensively invaded by metastases and yet not show bone destruction in the roentgenograms. They quoted the findings of Young and Funk in patients dying of carcinoma that 41 per cent. had metastatic lesions in the vertebrae; in only a few of the patients were the lesions seen in the roentgenograms. They do not believe that it is possible to avoid an occasional erroneous diagnosis and, at operation, to find a metastatic lesion in place of a herniated disc. They justified operation for relief of nerve-root pressure which causes symptoms and stated that four of nine patients in their series obtained relief from pain because of the erroneous diagnosis, whereas four of ten patients had been operated upon as a positive measure with the full realization that a metastatic lesion was probably present.

Dr. J. Vernon Luck [14] teased Dr. Key about some earlier doubts which he had expressed on whether or not a herniated disc really existed but lauded him for his present approach to the problem and concurred in the operative removal of metastatic lesions causing symptoms.

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[8] 742 Park Avenue, New York 21, N. Y.
[9] 742 Park Avenue, New York 21, N. Y.
[10] New York, N. Y.
[11] 1105 Amsterdam Avenue, New York 25, N. Y.
[12] 600 South Kingshighway, St. Louis 10, Missouri.
[13] 4952 Maryland Avenue, St. Louis 8, Missouri.
[14] 1930 Wilshire Boulevard, Los Angeles 5, California.

Dr. Gerald G. Gill[15] emphasized the danger that myelography may cause subsequent arachnoidal symptoms or cysts. He agreed that an aggressive surgical attack upon these lesions gives a more exact diagnosis of the metastatic deposit and affords a surgical decompression, giving the patient symptomatic relief.

The Prevention of Delayed Union or Non-Union in the Treatment of Fractures. **Dr. Edward L. Compere**[16] reported that chemicals, hormones, and vitamins are of little value in preventing delayed union or non-union. He thinks that local factors are more important and that the physician is often at fault in not controlling these. Distraction, caused by too much traction or by the bone ends being held apart by a metal plate, is a frequent cause of non-union. Poor reduction, either due to faulty technique or to interposition of soft tissues, is another common cause; inadequate immobilization is a third cause. Avascularization of the fragmented ends, by trauma or by constricting wires and bands, may also be a cause. Dr. Compere noted that a little motion is supposed to stimulate callus formation, such as that in treatment in a hanging cast or in Russell traction; he did not attempt to define when this "little" motion became inadequate immobilization. He feels that compression of the fragmented bone ends is useful in obtaining union and that compression can be effected by means of an intramedullary nail or an Egger's plate. The use of osteoperiosteal bone-graft slivers tended to hasten union.

In the discussion, **Dr. Frank G. Murphy**[17] noted that, since 1937, the number of fractures treated in Cook County Hospital had decreased by about two-fifths but that the number of non-unions had increased by two and a half times. He attributed this largely to unwarranted operative interference.

Dr. Marshall R. Urist[18] preferred the use of the term "separation" rather than "distraction," because oblique fractures which are overpulled heal well if contact of the fragments is maintained. He feels that motion, as well as separation of the fragmented ends, is a strong factor in non-union, and he stated that, regardless of the cause, the actual mechanism of non-union in all instances is the development of fibrinoid degeneration in the callus.

Wednesday, June 23

The Use of Internal Fixation in Compound Fractures of the Extremities. **Dr. H. Philip Dohn**[19] held that high-speed automobiles and the mechanization of the farm and factory have resulted in a greater number of compound fractures. Many compound fractures are accompanied by considerable damage to skin and other soft tissues. Of 323 compound fractures, the author had treated 209 by some form of internal fixation as primary treatment. Plates and screws were used in some; screws were used alone in others, and transfixion pins or intramedullary fixation was used in a few. The time of the operation varied from half an hour after injury to fourteen hours after injury. Fracture was in the lower extremity in 68 per cent., and, of these, the tibia and fibula were involved in 80 per cent. The great majority of the fractures were at the level of the junction of the middle third and lower third of the shaft. Of the compound fractures, 10 per cent. involved the femoral shaft. Most of the compound wounds he saw occurred from within outward.

Four aspects in the operative therapy were stressed, — complete débridement, thorough irrigation, removal of all devitalized tissue, and firm fixation with a minimum amount of metal. The wounds were usually closed and were supported in a circular plaster cast. Antibiotics were used routinely, postoperatively. In the 209 compound fractures treated in this fashion, postoperative infection, with drainage, developed in 17 per cent., but in only two instances did the author feel that frank osteomyelitis had ensued. Four patients required skin-grafting; amputation was necessary in three. The average length of hospitalization following treatment of a compound fracture was two weeks. The average time before the patient returned to work was six months for those with tibial fractures and was nine and a half months for those with fractures of the femur. Dr. Dohn believes that the incidence of infection in this series was no higher than it would have been in a series of similar injuries treated without internal fixation. He believes that union occurred as rapidly with this method as with other methods of therapy. Non-union of the fractured femur occurred in 20 per cent. and of the fractured tibia, in 19 per cent.

Pigeon-Breast, Funnel-Chest, and Other Congenital Deformities of the Anterior Chest Wall. **Dr. Charles W. Lester**[20] pointed out that pigeon-breast is a protrusion deformity of the sternum which usually occurs in the mid-line or it may be lateral and involve the costochondral junction. It may occur in such a way that the sternum protrudes obliquely. He believes, as a result of his studies, that disproportionate growth of the ribs can account for all the various protrusion deformities. This explains why the deformities seldom occur in children until they are four or five years of age and why the deformity increases as long as growth continues. As some ribs grow proportionately longer in some than in others, the sternum is buckled along the costochondral junction and is pushed forward in an arc. If overgrowth of the lower ribs occurs, the lower

[15] 655 Sutter Street, San Francisco, California.
[16] 116 North Michigan Avenue, Chicago 3, Illinois.
[17] 9204 Commercial Avenue, Chicago 17, Illinois.
[18] 1019 Gayley Avenue, Los Angeles 24, California.
[19] 525 Seventh Street, Eureka, California.
[20] 70 East 80th Street, New York, N. Y.

end of the sternum is forced to protrude more than is usual. Disproportionate growth of the ribs of one side may cause the oblique type of deformity. Patients with the oblique type of deformity often have symptoms referable to the cardiorespiratory system, such as chronic cough, wheeze, and exercise intolerance. They may appear thin and undernourished. The heart symptoms are explained on the theory that the large space between the heart and the sternum allows the heart to rotate during systole. This motion is transmitted to the great vessels and acts to constrict them just at the time they should be carrying a greater load. Surgical correction is based on the principle of thorocoplasty. Twenty-one operations were performed on seventeen patients and resulted in the correction of the deformity, correction of the physical limitations, and satisfaction of the patients. For mid-line deformities, the sternum is resected subperiosteally from the xyphoid to the second sternal segment. The posterior periosteum is left intact, and most of the anterior periosteum is preserved. The involved ribs are resected subperichondrially. The protrusion disappears and the cartilaginous and bony sectors regenerate in a normal position. Since the removed bone is in the mid-line, no paradoxical respiratory motion develops. In lateral deformities, the protruding portion of the ribs is dissected, and the same effect is achieved. Since rather extensive removal of the ribs may be necessary in some patients, the operation can be done in two stages in order to prevent paradoxical respiratory motion.

Funnel-chest is caused by a depression deformity and is characterized by a funnel-shaped depression, with the deepest point at the level of the xyphoid. It is usually present at birth; but, since the bony structures are relatively normal at this time, the depression is seen only on inspiration when the child cries. It is caused by a short central tendon of the diaphragm, as originally described by Brown. The deformity becomes worse with subsequent growth of the child. Since the shortening of the tendon of the diaphragm is not always confined to the mid-portion, one side of the sternum may be pulled inward more deeply than the other. The depression of the sternum displaces the heart into the left portion of the chest, and, in marked cases, interferes with its action in much the same manner as does constrictive pericarditis. If the heart does not move into the left portion of the chest, even a mild depression can produce definite heart symptoms, with changes seen on the electrocardiogram and a systolic murmur. These changes may vary from minimal to those which cause the patient to become bedridden or even to die. Most patients exhibit some degree of exercise intolerance, are underweight, and have poor posture. The vital capacity of the lung is frequently decreased by 25 per cent. An ineffectual cough is common; it is caused by the restricted motion of the diaphragm. The treatment of the funnel-chest deformity is surgical.

The radical operation for funnel-chest is done after the age of three, when the deformity has become established. It consists in the subperichondrial resection of the seventh to the third costal cartilages from the sternum; a transverse wedge osteotomy is done across the third sternal segment. The xyphoid is detached from the sternum, together with the intervening intercostal bundle. The substernal ligament is divided completely, and the ventral mediastinum is entered. The loose tissues are pushed off from the posterior section of the sternum, and the sternum is elevated by breaking it along the line of the wedge osteotomy. The position of the sternum is maintained by the simple suture of the periosteum across the osteotomy site. In some patients, however, it seems safer to pass a pair of stainless steel wires under the sternum, from side to side; these are attached externally to a transverse metal support or ladder. This outside support prevents paradoxical respiratory motion during crying and coughing; it may be removed in ten days. Occasionally, in place of the steel wires, a section of the rib is passed beneath the sternum and is anchored to the resected ends of the fourth ribs, as described by Daley. This method of fixation is valuable in women whose breasts interfere with the proper application of the external support.

A modification of the radical operation is used in children between the ages of fifteen and thirty months. In this, the cartilages are resected, and the wedge osteotomy is done at a lower level. Suturing of the periosteum across the osteotomy usually maintains the position of the sternum.

The simple operation, as originally described by Brown, is used only to relieve the pull of the diaphragm. It is accomplished by resecting the second costal cartilages and the costal arches, by detaching the xyphoid and the seventh rib beds from the sternum, and by transecting the substernal ligament. This operation is suitable only when the deformity has not become established in infants. Since the pleurae are away from the operative field, the use of intratracheal anaesthesia is unnecessary.

Dr. Lester reported ninety-four operations on ninety patients with funnel chests, the simple operation being done in eighteen patients, the modified being done in twelve patients and the radical being done in all others. In eight of the radical operations, the strut was used to maintain the elevation of the sternum. Four patients were subjected to re-operation. Two of these, early in the series, had had the simple operation done when a more radical procedure was indicated; two were frank recurrences. In all of the other patients, good functional results were obtained, but in some there was a certain degree of residual depression. In patients over five or six years old, certain irreversible changes, such as a downward slant of the ribs and a flat chest, cannot be completely corrected.

In the discussion, DR. A. LINCOLN BROWN[21] confirmed the findings of the author and complimented him on his excellent series.

[21] 490 Post Street, San Francisco 2, California.

Dr. F. Henry Ellis, Jr.,[22] confined his remarks chiefly to a discussion of funnel-chest, and stated that the ideal age for operation is between three and five years. He stated that, at the Mayo Clinic, the results with the simple operation had not been uniformly successful. At the Clinic, they believe that operation on infants can be postponed until the child is well past one year of age, at which time it is feasible to carry out the radical operation. Dr. Ellis had had no experience with the modified procedure described by the author. At the Clinic, the radical operation described by the author is usually performed. Some form of extraskeletal traction, maintained for ten days following operation, is usually employed.

Dr. J. Warren White[23] told of two infants successfully treated by a simple rubber-suction device, the common "plumber's helper", applied externally on the surface of the child's chest.

Chairman's Address. A Critical Analysis of the Fracture Problem. Dr. Charles N. Pease[24]. This address has been published in full in *The Journal of the American Medical Association,* **156:** 805–807, Oct. 30, 1954.

The Results of Stabilizing Spine Fusion in Cases of Previous Herniated-Disc Removal without Fusion. Dr. Alfonso Della Pietra[25] reported on forty-three patients previously operated upon for herniated disc, without stabilization of the spine, who continued to be disabled. In these, he had attempted salvage. Four patients proved to have had a pathological condition other than that of the disc; a good result in only one of these was obtained by means of a stabilization procedure. A review of all of the patients showed that only three had not had a preoperative myelogram made. Six had had two myelograms made, and two had had three myelograms made. Of the patients who had had a myelogram made, 87 per cent. showed residual pantopaque in the dural canal; no definite relationship was noted between the severity of the complaints and the amount of residual pantopaque. However, 61 per cent. of the patients had varying amounts of pantopaque in the cranial vault. In one instance, it was possible to associate definitely the residual pantopaque with the severe pain in the left orbital cavity. Twenty-five patients were subjected to re-exploration and fusion by Dr. Della Pietra. The constant surgical finding was a mass of scar tissue in the previous operative area. This made the second exploration extremely difficult. Scar tissue enveloped the dura, as well as the nerve roots; this finding indicated that a simple neurosurgical exploration of the disc causes as much scarring as an exploration followed by a fusion. In only two patients was new extruded disc material found. In twenty-one of the twenty-five patients operated upon, solid spine fusion, as seen in bending roentgenograms, was obtained. Fifteen of these were well and the result was classified as excellent. The result in four was classified as good, since the patients were able to return to work, even though they still had some pain. In two patients with solid fusions, the results were poor and the patients were unable to work.

Acute Calcific Deposits in the Hand. Dr. Robert Carroll[26] and Dr. Alexander Garcia[27] reported that calcium deposits in the tissues of the hand are not uncommon. Recognition of their presence is based on acute pain, localized tenderness, redness, swelling, and loss of motion. Roentgenograms, made in the proper planes and angles, will show the deposits; however, they may be missed if roentgenograms are not correctly made. In a review of 100 cases, Dr. Carroll and Dr. Garcia pointed out that the pain was often agonizing and did awaken some of the patients during the night. There was marked swelling, with localized tenderness; the redness frequently simulated an infection, with streaking of the sort seen in lymphangiitis. A third of the patients gave a history of preceding strain. They sometimes had an elevated sedimentation rate. At operation, in a few patients, the deposits were discovered to be in or near the small joints of the carpus or the phalanges. Some deposits, however, lay within the tendon or the ligament or in the layers of the joint capsule. Regardless of the type of therapy used, the symptoms cleared and the roentgen shadows of calcium disappeared within two or three weeks. Dr. Carroll and Dr. Garcia feel that operative intervention is unnecessary. Novocain injections, hot soaks, and splinting are advocated. No recurrences have been observed. No mention was made of roentgen therapy, which the discussors felt had been helpful in some instances.

Thursday, June 24

Dual Pinning in Supracondylar Fracture of the Femur. Dr. Dana M. Street[28] and Dr. Anibal L. Lugo[29] gave a historical review of the treatment of supracondylar fracture of the femur and a discussion of the problem of controlling the small distal fragments so frequently pulled into flexion by the gastrocnemius. Fifteen patients were treated by the two-pin method of Rush, in which slightly curved Rush pins are driven through the medial and lateral femoral condyles, up into the shaft of the femur, to engage the far cortex of the shaft at a source of immobilization. Although the procedure is not easy technically, and although it may be complicated by the pin's backing outward or going too far into the femoral condyle, due to soft bone in the aged, this method has the advantage of good stability and permits early motion (without a plaster cylinder), early ambulation, and the maintenance of good joint motion. The pin should extend well up into the narrow part of the medullary canal in order to provide the greatest stability. The details of technique were discussed and roentgenograms of seven cases illustrated the technique.

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[22] Mayo Clinic, Rochester, Minnesota.
[23] 350 South Hotel Street, Honolulu, Hawaii.
[24] 104 South Michigan Avenue, Chicago 3, Illinois.
[25] 3 Second Avenue, Waterbury, Connecticut.
[26] 180 Fort Washington Avenue, New York 32, N. Y.
[27] 180 Fort Washington Avenue, New York 32, N. Y.
[28] Kennedy Veterans Hospital, Memphis 15, Tennessee.
[29] San Juan, Puerto Rico.

The discussion by Dr. I. E. Hendryson[30] and Dr. Donald D. Slocum[31] brought out more fully the technical difficulty of the procedure but showed its value in the management of complicated multiple fractures of both extremities. They thought that tibial skeletal traction, with the knee flexed, was the method of choice, except in special instances in which the dual pinning had a distinct advantage.

The Prevention and Correction of Adduction Contracture of the Thumb. Dr. J. William Littler[32] reported that an adduction deformity of the thumb constitutes a very disabling structural derangement. The basic function of the thumb is to oppose itself against the fingers. A fixed adduction contracture renders this function ineffective. These contractures may result from faulty immobilization in plaster or from too prolonged splinting. A tight dressing under the plaster may allow secondary stiffening of the carpometacarpal joint and contracture of the cutaneous web. Scar contractures of the web secondary to burns and other trauma may be a cause. The common severe cause is ischaemic contracture of the intrinsic muscles. A less common cause is injury to the median and ulnar nerves, or even wrist-drop resulting from a radial-nerve paralysis when the long thumb extensor becomes adherent within the fibrous sheath at the wrist. Local destruction of soft tissue overlying the base of the thumb or crushing injuries to the hand may produce this deformity. Correction of the deformity, if it is not too severe, can be accomplished in some patients by means of abduction traction-splinting alone, if it is begun early. Long-standing adduction contractures, however, require surgical intervention. In the less severe cases, a Z-plasty of the contracted web may be done. In burns, when the skin alone is involved, replacement of the scar by a split-thickness skin graft is effective. When deeper structures are involved, however, with loss of tissue, a pedicle skin flap is required, but, during the pedicle-graft procedure, the thumb must be held in abduction by a Kirschner wire. In very extensive cases, the index finger may be so damaged that removal is required. In these, excision of the second metacarpal at its base provides a good opening for the formation of a web between the thumb and the remaining middle finger. In most cases of adduction contracture, the fibrous interosseous musculature and fascia must be excised in order to mobilize the first metacarpal when the pedicle graft is set in place. If mobility cannot be gained and maintained, the thumb must be fixed in a good position of function, since position and stability are essential. The author prefers to use a bone-strut graft between the first and second metacarpals rather than to do a fusion of the carpometacarpal joint. He believes that arthrodesis of the thumb metacarpal should be a last resort.

In the discussion, Dr. Lot D. Howard[33] said that traction-splinting is not of value in correcting the deformity. Surgical excision of scar, with pedicle skin-grafting, was advised.

Transplantation of Biceps Femoris to the Patella by the Medial Route in Poliomyelitic Quadriceps Paralysis. Dr. Gene D. Caldwell[34] compared twenty-eight transplantations of the biceps femoris, alone, to the patella by the lateral route or in combination with the semitendinosus, with a later series of forty-one transplantations of the biceps femoris, alone, by the medial route. The use of the medial route eliminates the objectionable dislocation of the patella which occurs when transplantation by the lateral route is done. Genu valgum does not occur. No instance of dislocation of the patella occurred following the transplantation by the medial route, whereas in 61 per cent. of those in whom the transplantation was done by the lateral route, dislocation of the patella occurred. Dr. Caldwell, however, noted very little difference in the functional end results between the two methods. The medial transplantation is indicated in cases of paralysis of the quadriceps in which either a brace or hand-to-knee walking is necessary in order to stabilize the knee. The biceps femoris to be transplanted should be of good normal power. Any fixed flexion deformity at the knee should be corrected prior to transplantation. A good hip extensor and a good gastrocnemius are helpful, but the absence of power in these does not contra-indicate this muscle transference. Genu recurvatum can still be expected to occur following the transplantation if the medial hamstrings and gastrocnemius are not functioning. At operation the biceps femoris is exposed by means of a long posterolateral longitudinal incision; the distal end of the muscle is divided at its insertion to the fibula. Tendon and muscle are dissected upward to the upper third of the thigh, so that the distal two thirds of the muscle, comprising the short head of the origin of the muscle, is detached from the femur. Damage to the perforating vessels must be avoided. The intermuscular septa are stripped from the linea aspera, and the biceps femoris is passed behind the femur to the medial side of the thigh, care being taken to avoid the constriction of the muscle between the intermuscular septa and the femur. The tendinous insertion is fastened firmly into the patella through an osseous tunnel. Dr. Caldwell emphasized that, despite the apparent indirect circuitous route of the transplanted muscle, the actual direction of the muscle pull is quite straight and is direct from the origin to the insertion of the muscle. Immobilization is maintained for a period of four weeks and active exercises are then begun. The follow-up study in transplantations done by the medial route averaged seven years. Failures were largely due to technical errors.

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[30] 1750 Race Street, Denver 6, Colorado.
[31] 431 Eugene Medical Center, Eugene, Oregon.
[32] 16 East 90th Street, New York, N. Y.
[33] 516 Sutter Street, San Francisco, California.
[34] 803 Jordan Street, Shreveport, Louisiana.

In discussion, **Dr. Frederic C. Bost** [35] emphasized that probably no paralytic condition of the lower extremity merits greater consideration than that of the weak knee due to a quadriceps paralysis. He stated that the author had presented a good review of the operative techniques for the relief of this condition and that his procedure avoided the objectionable feature of dislocation of the patella. He thought that the origin of the biceps femoris might perhaps be transplanted in such a way as to make a true quadriceps of it, — that is, making it run in a straight line down to the patella — since, by surgical technique, its nerve and blood supply can be preserved in order to permit this type of free muscle transplantation.

Dr. Nicholas Giannestras [36] confirmed the value of the procedure on the basis of his personal experience and showed its use in a case of traumatic loss of the quadriceps. This resulted in an excellent recovery.

Bryant's Traction, a Provocative Cause of Circulatory Disturbance. **Dr. Jesse T. Nicholson** [37], **Dr. Robert M. Foster** [38], and **Dr. Robert D. Heath** [39] dealt with the complications of Bryant's traction, — a procedure which most physicians have long believed to be perfectly safe. They presented six cases of circulatory complications. In the milder form, the complication is an ischaemic fibrosis of the muscles of the lower portion of the leg, resulting in a residual equinovarus deformity which can readily be mistaken for a mild peroneal-nerve paralysis. In the more severe condition, there is a circumferential band of skin necrosis and of muscle necrosis in the muscles of the calf. In the most severe form, definite gangrene of the foot occurs. The majority of these complications occurred in the sound extremity held vertically in Bryant's traction and not in the injured limb. The authors investigated the blood pressure in legs elevated to various degrees beyond the vertical by taking blood-pressure readings at the ankle. They found that the blood pressure was adequate in children under two years of age, that it was precarious in children from the ages of two to four, and that it was dangerously impaired in legs in the vertical position in all children above four years of age. For example, at six years of age, the mean blood pressure must be at least 45 millimeters of mercury in order to maintain circulation in a leg held in the vertical position. If the knee is hyperextended in a child younger than two years, the blood pressure is not affected; between two and four years of age the circulation becomes precarious, and above four years of age, in all cases, circulation stops at the level of the femoral condyle. Other factors influencing the circulation in the limb are shock, traction, osteochondromatous growths, bandaging over the adhesive traction, and active exercise.

In the discussion by **Dr. Robert J. Joplin** [40] it was emphasized that in the original article by Thomas Bryant, in 1876, only children under three years of age were advised to be treated by this method. Bryant also advised fixing the limb in some light splint; this may have been advised in order to prevent hyperextension of the knee.

Dr. Edward G. Ewer [41] reiterated the importance of treating no child over the age of two and a half by Bryant's traction.

This excellent article, when it appears in *The Journal of the American Medical Association* should be carefully studied by all physicians treating fractures in children.

Interbody Spinal Fusion: Preliminary Report. **Dr. John R. Stacy** [42] and **Dr. Earl D. McBride** [43] reported on fifty-seven interbody spine fusions, in thirty of which the interbody graft was used alone, and in twenty of which the interbody graft was combined with a mortised facet-block graft. They do not recommend the routine use of the procedure, but they feel that it is indicated in spondylolisthesis and spondylolysis and that it can be used after procedures which result in abnormal instability of the vertebrae, such as extensive laminectomy and facetectomy, and after large amounts of fragmented disc material have been removed. When other methods fail to give sufficient stability for rapid postoperative rehabilitation, the procedure can be used to advantage. The technique varied in their hands. After exploration in the usual manner for a disc, the lateral wall of the spinal canal was removed in some. This allowed access to the disc space with little or no traction on the nerve roots or dura. In others, the nerve roots were gently retracted without the removal of the lateral wall of the spinal canal, and the spinous processes were widely spread with special bone forceps. In each, however, the cartilage disc was curetted out, together with some of the underlying bone plate of each vertebral body, and bone grafts in the form of small chips taken from the spinous process or the ilium were inserted. Complications were reported as being temporary and minimal. Three had mild paresis of the muscles of the lower extremity, which recovered. One infection occurred, the draining sinus healing in eight months. There was one postoperative thrombophlebitis. Three patients required re-operation, and in none of these was any protrusion of the grafted material noted. The clinical results were analyzed on the basis of the length of time before the patients returned to their usual activities, this averaged 3.5 months. The average hospital stay was sixteen days. Fifteen patients had no postoperative support in the form of a brace. The results in 84 per cent. of the patients are classified as excellent and in 13 per cent. as fair. Postoperative roentgenographic studies, with biplane bending roentgenograms, were made of forty-eight of the fifty-seven patients. Narrowing of the disc space was noted in 78 per cent. Dr. Stacy and Dr. McBride did not note complete body consolidation, with trabeculae growing across the disc space to each vertebral body. They felt that many had obtained osteofibrous ankylosis only. Failure of fusion between the fourth and fifth vertebral bodies occurred in three of forty-four patients. All of the twenty-nine lumbosacral fusions attempted became solid. Mention was made of the experimental introduction of lead and magnesium and growth-hormone powder in order to stimulate bone formation, but no conclusions could be drawn from this work.

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[35] 384 Post Street, San Francisco 8, California.
[36] 811 Doctors Building, Cincinnati 2, Ohio.
[37] 330 South Ninth Street, Philadelphia 7, Pennsylvania.
[38] Philadelphia, Pennsylvania.
[39] Philadelphia, Pennsylvania.
[40] 1180 Beacon Street, Boston 46, Massachusetts.
[41] 1624 Franklin Street, Oakland 12, California.
[42] 605 Northwest Tenth Street, Oklahoma City 3, Oklahoma.
[43] 605 Northwest Tenth Street, Oklahoma City 3, Oklahoma.

In the discussion by **Dr. H. Relton McCarroll** [44], the dangers of this procedure were outlined and it was pointed out that the standard spine-fusion procedure held none of these risks.

Dr. Douglas D. Toffelmier [45] drew attention to the method of Gill for the removal of the posterior arch in spondylolisthesis without fusion being necessary.

Vitallium-Mold Arthroplasty of the Hip: An End-Result Study. **Dr. George Hammond** [46], **Dr. Howard R. Crawford** [47], and **Dr. G. Edmund Haggart** [48] reported that, from June 1931 to January 1953, 114 Vitallium-mold arthroplasties of the hip for various disabilities were performed at the Lahey Clinic upon 104 patients. Of these, 85 per cent. were between the ages of twenty and fifty-nine years, and 58 per cent. were females. For the young patient with unilateral hip-joint disease, arthrodesis is advised, but arthroplasty is considered to be the procedure of choice in patients with bilateral hip disability. Vigorous, muscular, physiologically young patients who are not overweight are the best candidates for the operation. The operative technique and postoperative care described by Smith-Petersen were largely employed. They attempted to have the mold ride in the acetabulum on the femur in a neutral position; they avoided a varus position. The edge of the mold should extend well beyond the margin of the acetabulum. There were thirty-seven complications occurring in twenty-eight patients. Wound infection occurred in nine hips; four patients had nonfatal pulmonary emboli; five dislocations of the cup in patients without infection occurred, as well as three subluxations of the cup. Patients with peroneal-nerve palsy and brachial plexus palsy recovered completely. One patient had been subjected to arthrodesis before a draining sinus revealed tuberculosis to be the cause of the destructive arthritis. There was no operative mortality. Secondary operative procedures included abductor tenotomies. It was necessary to revise the mold arthroplasty in thirteen hips (11 per cent.), because of distressing pain or limited motion. Ligation of veins was performed in some before the advent of anticoagulant therapy. Three arthrodeses were performed because of failure of the mold arthroplasty. End-result study was done on all patients, at least two years postoperatively. A detailed questionnaire was used, in addition to personal interviews, and a thorough orthopaedic examination which included roentgenographic examination of the pelvis. Of the total, 79 per cent. were reviewed in this manner, the average follow-up being over seven years. The investigation of the end results was carried out by physicians who were not associated with the actual surgical procedures. It was found that results established on the basis of questionnaires were often erroneous; the clinical examination of the patient was less subject to error. From the patients' standpoint, the subjective end results showed that 78 per cent. of the hips had been improved by surgery, 46 per cent. of these being classified good or excellent. From the surgeon's standpoint, however, an objective end-result study revealed that percentage of those which had been improved was reduced to 62 per cent., of which 39 per cent. were excellent and 38 per cent. were poor. The authors attempted to form a composite end result from their study of the subjective and objective end results. They concluded that 51 per cent. of the hips were improved, that in 37 per cent. the results were good or excellent, and that in 38 per cent. the results were poor. These closely approximated the objective end results. The poorest results occurred in arthroplasties in patients with pyogenic arthritis. The authors concluded from this study that, with a careful selection of patients, scrupulous operative technique, and effective postoperative care, the Vitallium-mold arthroplasty of the hip has a definite place in the treatment of disabilities of the hip joint.

[44] 3720 Washington Boulevard, St. Louis 8, Missouri.
[45] 354 21st Street, Oakland 12, California.
[46] Lahey Clinic, Boston, Massachusetts.
[47] Lahey Clinic, Boston, Massachusetts.
[48] Lahey Clinic, Boston, Massachusetts.

Officers elected for the ensuing year are as follows:
Chairman: Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania;
Vice-Chairman: William T. Green, M.D., Boston, Massachusetts;
Secretary: Frederick R. Thompson, New York, N. Y.;
Representative to Scientific Exhibit: J. Vernon Luck, M.D., Los Angeles, California;
Executive Committee: H. Relton McCarroll, M.D., St. Louis, Missouri,
Charles N. Pease, M.D., Chicago, Illinois,
Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania,
Frederick R. Thompson, M.D., New York, N. Y.,
Edward L. Compere, M.D., Chicago, Illinois.

EXCHANGE FELLOWSHIPS

In 1955 the program of Exchange Fellowships between Great Britain and North America, sponsored jointly by The American Orthopaedic Association, The British Orthopaedic Association, and The Canadian Orthopaedic Association, will send five Fellows from North America to Great Britain where they will be guests of The British Orthopaedic Association. Four Fellows will be selected from the United States and one from Canada.

The American Orthopaedic Association contributes $500.00 toward the traveling expenses of each Fellow from the United States; The Canadian Orthopaedic Association contributes $500.00 to the Fellow chosen from Canada, and The British Orthopaedic Association contributes the sterling equivalent of $500.00 to each of the five candidates toward their expenses while in Great Britain.

The tentative program calls for the Fellows to arrive in Great Britain about the first of May, join The British Orthopaedic Association in its visit to the *Société française d'Orthopédie et de Traumatologie* in Paris on May 5, 6, and 7, and then return to spend five or six weeks at orthopaedic centers in Great Britain.

The Committee on Exchange Fellowships both of The American Orthopaedic Association and of The Canadian Orthopaedic Association invite any young orthopaedic surgeon in the United States or Canada who may be interested in going to Great Britain in 1955 as an Exchange Fellow to make application at once to the Secretary of The American Orthopaedic Association (in the case of candidates from the United States) or to the Secretary of The Canadian Orthopaedic Association (in the case of candidates from Canada) in order that their qualifications may be considered by the selection Committee.

Applicants should be not more than forty years of age; they should have completed their training in orthopaedic surgery; they should have passed the examinations of The American Board of Orthopaedic Surgery or the Royal College of Physicians and Surgeons of Canada, and they should be established in the active practice of some branch of orthopaedic surgery (university teaching, clinic practice, private practice, or research).

Applicants should submit details of their education, training in orthopaedic surgery, appointments past and present, military service, and contributions to surgical literature. Forms for this purpose may be obtained from the Secretaries of The American Orthopaedic Association and The Canadian Orthopaedic Association, or from members of these Associations and from Fellows of The American Academy of Orthopaedic Surgeons. The application should be supported by two sponsors, members of The American Orthopaedic Association, Fellows of The American Academy of Orthopaedic Surgeons, or members of The Canadian Orthopaedic Association. Endorsement by the chief of the orthopaedic service where the candidate has had most of his orthopaedic training would be valuable to the selection Committee.

Will members of The American Orthopaedic Association and The Canadian Orthopaedic Association and Fellows of The American Academy of Orthopaedic Surgeons please call this opportunity to the attention of their young colleagues and support the application of those who they believe would benefit.

The closing date for applications will be December 31, 1954.

News Notes

The Twenty-second Annual Meeting of **The American Academy of Orthopaedic Surgeons,** under the presidency of Dr. T. Campbell Thompson of New York City, will be held at the Hotel Statler, Los Angeles, California, January 29 to February 3, 1955.

The 1955 Annual Meeting of **The American Orthopaedic Association** will be held at The Greenbrier, White Sulphur Springs, West Virginia, June 19 to 22.

The American Board of Orthopaedic Surgery has announced that examinations are to be held as follows:

Part II Examinations on January 27 and 28, 1955, at Los Angeles.

Part I Examinations at various locations in April 1955.

Deadline for receipt of applications is November 30. They should be made to the Secretary, Dr. Harold A. Sofield, 122 S. Michigan Avenue, Chicago 3, Illinois.

The Tenth Annual Meeting of the **American Society for Surgery of the Hand** will be held at the Biltmore Hotel, Los Angeles, California, on Friday, January 28, 1955. The preliminary program includes the following papers:

Tumors of the Hand.
  Joseph L. Posch, M.D., Detroit, Michigan.
Tuberculosis of the Hand.
  Philip H. Moore, M.D., Mt. Edgecumbe, Alaska (by invitation).
Providing Automatic Grasp by Flexor Tenodesis.
  James N. Wilson, M.D., Los Angeles, California.
Congenital Subluxation of the Thumb into the Palm.
  Elden C. Weckesser, M.D., Cleveland, Ohio.
Vasomotor Reactivity in Dupuytren's Contracture.
  F. X. Paletta, M.D., St. Louis, Missouri (by invitation).
Surgery of Rheumatic Hands.
  Sterling Bunnell, M.D., San Francisco, California.
Volkmann's Contracture.
  J. Leonard Goldner, M.D., Durham, North Carolina.
Congenital Absence of the Radius.
  Daniel C. Riordan, M.D., New Orleans, Louisiana.
Adduction Contracture of Thumb.
  J. Edward Flynn, M.D., Boston, Massachusetts.

An interesting article entitled "Effect of Outer Fiber Stress on Brace Design" has been prepared by Francis L. Smith and Dr. John L. Young of the **Sarah Mellon Scaife Foundation's** Multiple Fellowship on Orthopaedic Appliances, of the Mellon Institute. Copies may be obtained upon request to: Mellon Institute, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.

Surgeons visiting Boston should note the change in the hours for Orthopaedic Grand Rounds at the Massachusetts General Hospital which will be held hereafter in the Bigelow Amphitheater, White Building 3A, at eleven o'clock in the morning.

Combined Rounds with Children's Hospital will be held, as in the past, at eight o'clock. The dates for these Rounds are: at Massachusetts General Hospital, on Wednesdays, December 15, 1954, February 16 and April 20, 1955; at Children's Hospital, on Tuesdays, January 18, March 15, and May 17, 1955.

The Fourteenth Japan Medical Congress will be held at Kyoto, April 1 to 5, 1955. The **Japanese Society of Orthopaedic Surgery** is one of the forty-one medical societies participating in this Congress. Meetings will take place at Kyoto University and Kyoto Prefectural Medical College. Additional information about the Congress may be obtained from the Secretary-General, Dr. Mitsuharu Goto, University Hospital, Medical Faculty of Kyoto University, Kyoto, Japan.

A Congress of the **International College of Surgeons** will be held at Geneva, Switzerland, from May 23 to 26, 1955, in celebration of the twentieth anniversary of its founding by Prof. Max Thorek. The present President is Prof. R. Nissen, Director of Surgery at the University Hospital of Bâle. The President of the Congress to be held in May is Prof. A. Jentzer; the Vice-Presidents are Dr. J. H. Oltramare of Geneva and Dr. A. Nicolet of Berne. Inquiries about the Congress may be made to the Secretary of the Congress, 6–8 rue de la Confédération, Geneva.

The Manual of Orthopaedic Surgery published by The American Orthopaedic Association with the cooperation of The American Academy of Orthopaedic Surgeons was made possible by the John R. Thompson Fund. This handbook has received enthusiastic acceptance by students, residents, and others who come in contact with orthopaedic problems. During the two years which have elapsed since publication, over 11,000 copies have been distributed.

Much interest in translations of the Manual has been expressed by Spanish, French, Portuguese, and Japanese orthopaedic surgeons.

The present Manual is distributed at cost. When it becomes self-supporting, the John R. Thompson Fund will be directed to the support of other educational activities in the field of orthopaedic surgery.

The Manual of Orthopaedic Surgery may be obtained for $1.08 per copy, with a discount of 15 per cent. for single orders of ten or more copies. Orders should be sent to the Central Office of The American Academy of Orthopaedic Surgeons, Inc., 122 South Michigan Avenue, Chicago 3, Illinois.

NEW JERSEY ORTHOPAEDIC SOCIETY

The Annual Meeting of the New Jersey Orthopaedic Society was held on Saturday, October 16, 1954, under the presidency of Dr. Henry H. Kessler, at the Kessler Institute for Rehabilitation, West Orange, New Jersey.

The following are the officers for the ensuing year:

President: John J. Flanagan, M.D., South Orange, New Jersey;
President-Elect: William Kruger, M.D., Newark, New Jersey;
Secretary: Arthur Thurm, M.D., Trenton, New Jersey;
Treasurer: Harold T. Hanson, South Orange, New Jersey.

The following scientific papers were presented:

Skin Coverage for Scars Adherent to Bone.
    S. R. LoVerne, M.D., and J. J. Amster, M.D., Orange, New Jersey
        Discussion by Jerome Gelb, M.D., Newark, New Jersey.
Charcot's Disease following Trauma.
    Saul I. Firtel, M.D., Newark, New Jersey.
Clinical Applications of Investigation on Bone Metabolism.
    Edward C. Reifenstein, M.D., Oklahoma City, Oklahoma.
Operative Treatment of Tibial Plateau Fractures.
    Harry N. Ein, M.D., and William B. Ein, M.D., Newark, New Jersey.
Use of Oxygen Pneumo-Arthrography of the Knee as a Diagnostic Tool (motion picture).
    C. A. Maxwell, M.D., Morristown, New Jersey.
Bilateral Degenerative Arthritis of Hips in Late Adolescence.
    Andrew C. Ruoff, III, M.D., Paterson, New Jersey.
The Use of Braces in Athetoid Type of Cerebral Palsy.
    Sidney Keats, M.D., Newark, New Jersey.
        Discussion by A. R. Shands, Jr., M.D., Wilmington, Delaware.
Slipped Femoral Capital Epiphysis with Postoperative Results.
    Philip Willner, M.D., Newark, New Jersey.
        Discussion by A. M. Rechtman, M.D., Philadelphia, Pennsylvania.

Book Reviews

Fractures and Orthopaedic Surgery for Nurses and Physiotherapists. Ed. 3. Arthur Naylor, Ch.M., M.B., M.Sc.(Sheff.), F.R.C.S.(Edin.), F.R.C.S.(Eng.). Edinburgh, E. & S. Livingstone Ltd., 22 shillings, 6 pence; Baltimore, The Williams & Wilkins Co., 1952. $5.00.

This book is in its Third Edition and presents a detailed discussion of the current treatment of orthopaedic disabilities in a most readable style. The illustrations are improved.

The chapter on Orthopedic Theatre Technique will be of interest particularly to the orthopaedic scrub nurse. There is good organization of material, and a brief, succinct discussion of all common orthopaedic disabilities, including symptoms, signs, and treatment.

The book may be recommended as an excellent basic orthopaedic text, not only for nurses and physiotherapists but for medical students, interns, general practitioners, and others who are interested in orthopaedic teaching.

Eugene E. Record, M.D.

Morris' Human Anatomy. A Complete Systematic Treatise. Ed. 11. Edited by J. Parsons Schaeffer, A.M., Ph.D., Sc.D., D.Litt. New York, The Blakiston Company, 1953. $16.00.

The appearance of the Eleventh Edition of this monumental textbook testifies to its importance. A review of any textbook of anatomy presents a difficult problem, because it must be known for which group of readers the text is created. Is it a reference book for the clinician and student, or is it a text for the systematic use of the medical student in his first years?

In as much as there has been a deplorable tendency in medical schools to shorten the time alloted to the study of anatomy, it would appear that the larger texts are not practical. This is not true. It is easier to read and to retain factual material from a larger treatise, than from a skeletonized and emasculated text. The utilization of the available short time given to the study of anatomy should be so arranged and guided that the student should be able to assimilate the larger text with ease.

The inspired teacher of anatomy has the responsibility not only to help the student to retain important anatomical facts, but also to give the student a persistent incentive to learn anatomy constantly to the last day of his active medical life.

It is the reviewer's personal opinion that *Morris' Human Anatomy* is well adapted to such demands.

The Eleventh Edition has been extensively revised and brought up to date; a few sections have been almost completely rewritten. The list of contributors includes the names of many well known anatomists; several of the names are especially familiar to orthopaedic surgeons.

It is especially pleasing to the reviewer to find that the modern tendency toward complete elimination of eponyms has not been followed here and that the use of eponyms is "continued in moderation in places befitting the text".

There are 1,607 pages of text, 1,198 illustrations, and an extensive index of 109 pages. The text is divided into sections in accordance with the traditional grouping of descriptive anatomy. The illustrations are ample, although a few more could have been added.

Throughout the text the relation to clinical medicine is mentioned wherever necessary, and the functional approach is maintained. The significance of the relationship of the bony structures to the viscera is indicated but not emphasized. General relationships are clearly brought out. The variations of structures are described, not catalogued, and emphasis is placed on the important ones, with an occasional explanation of their significance.

The sections of specific interest to the orthopaedic surgeon—osteology, arthrology, myology, and neurology—include original material from investigations by their respective contributors. There are many suggestions of a clinical nature which may be very useful to the orthopaedic surgeon. The introductory chapter of the section on myology is comprehensive. At the end of the section on myology there is a chapter grouping muscles according to their function, with line diagrams indicating the important axes of action of the joints.

Each section has a brief bibliography with references to significant recent literature and classic works. The inclusion of the selective bibliography is of great help.

The reading of the text shows the excellence of each contribution and the magnificent work in the coordination and integration of the material by the editor.

Morris' Human Anatomy can be used with great profit by the medical student in the beginning of his anatomical indoctrination; it can be used as a reference book by the clinician, who cannot always spare time for consultation of more extensive treatises. It can also be utilized by the, *horribile dictu*, orthopaedic anatomist, who may find here helpful information on many subjects.

Emanuel B. Kaplan, M.D.

PAIN SYNDROMES AND THEIR TREATMENT. With Special Reference to Shoulder-arm Pain. James M. Tarsy, M.D. Springfield, Illinois, Charles C. Thomas, 1953. $12.00.

The author's intention appears to have been to write an encyclopaedic compendium of painful lesions of the neck, shoulder, and thoracic spinal structures; in a sense he has succeeded. This field, however, is one in which organization of material is difficult to achieve; in this respect he has been less successful. He has drawn heavily on the literature and has presented the theoretical material with little critical evaluation and with a regrettable objectivity which does not sufficiently reflect his own experience. Moreover, there has been reliance chiefly on older rather than recent literature. Although an ancillary bibliography refers to the best of recent work, there is less evidence of the influence of recent work in the text than there is of the writings of two or three decades ago. The result is at times an anachronistic reference to the clinical landmarks of another era, such as tuberculosis and syphilitic spondylitis as common causes of cervical radicular pain. The author's preference for the posterior approach for injection of the stellate ganglion, which most practitioners of the procedure have now discarded, may have the same origin.

He is at his best in describing anatomy in terms of function, and the chapter on the anatomy of the shoulder is a very good one. However, when the text describes neurological anatomy, it is neither so clear nor so inviting to the reader. When the clinical discussion for differential diagnosis enters other fields, such as neurology and neurosurgery, the advice is at times insecure and meager. The discussion of cervical-disc rupture, that is, conservative as against operative management, is quite scanty and hardly provides the reader with enough information to help him to form his own opinion. The relationship between disc protrusion and spondylitis is discussed as if they were two entirely separate entities, rather than the closely associated conditions they actually are.

The photographs are excellent and show in detail how to examine a patient with pain of obscure origin. However, one may well ask if the practitioner-reader to whom these illustrations are offered should be encouraged by drawings implying ease of performance to attempt such procedures as thoracic-nerve block and brachial-plexus block; these are hardly for the tyro. There is only a casual mention of the occurrence of neuritis following the injection of alcohol.

Unfortunately, the writing is awkward and the proof-reading has been regrettably poor in both text and bibliography; these defects perhaps can be remedied in a later edition.

Samuel Lowis, M.D.

THE MANAGEMENT OF PAIN. With Special Emphasis on the Use of Analgesic Block in Diagnosis, Prognosis and Therapy. John J. Bonica, M.D. Philadelphia, Lea & Febiger, 1953. $20.00.

No problem is of more universal concern than that of pain, because it is so often the most urgent presenting sympton, the most destructive force psychologically, and the most disabling factor socially in illness. Dr. Bonica has performed an outstanding service in offering this exhaustive treatise upon a tremendous subject.

The publishers have produced a volume which is a handsome addition to any library. The format is good; the excellent paper and good type make reading pleasant. The many photographs are particularly notable for their clear reproduction.

The subject matter of *The Management of Pain* has been dealt with by the author in three sections, each of which might well constitute a book. Part I, entitled "Fundamental Considerations", presents first a chapter upon the anatomy of the nervous system as related to the perception of pain and the structures and pathways by which pain impulses are transmitted. Then follow chapters dealing with the physiological, pathological, and psychological bases of pain, and a discussion of its mental and physical effects.

Part II is concerned with Methods in Management of Pain. As is indicated in the title of the book, the use of analgesic block is emphasized, and the bulk of this section is concerned with it, other methods being considered as adjuvants. The relegation of certain procedures, such as neurosurgery and psychiatric treatment, to this role might be questioned. In any case, the point is stressed that each pain problem is individual and involves careful evaluation, choice, and combination of available methods of treatment.

Part III, "Pain Syndromes", occupies the remainder, more than half of the more than 1,500 pages. Here the author undertakes to describe in some detail all the conditions in which pain may appear as a symptom. Material which lends itself to such treatment is combined into tables; this facilitates reference. This section of the book is particularly valuable to all members of the medical profession, regardless of specialty.

It should be added that the most impressive thing about the book is the author's intrepid approach to the problem. At the conclusion of his preface, he states his position as follows: "Meanwhile, all physicians must concern themselves with this problem, for pain is the day by day business of every doctor. We must make an effort to give the various painful states an intelligent appraisal; and, perhaps equally important, we must formulate a systematic plan for relief which will conserve the patients' social usefulness in so far as possible. In other words, we must manage pain as best we can, for even if in a crude and empirical manner we can alleviate some patients of their suffering, our efforts will be worthwhile. The proper management of pain remains, after all, the most important obligation, the main objective, and the crowning achievement of every physician."

Julia G. Arrowood, M.D.

OFFICE ORTHOPEDICS. Ed 2. Lewis Cozen, M.D., F.A.C.S. Philadelphia, Lea & Febiger, 1953. $5.50.

The new Edition of this concise and practical text, in comparison with the previous one, contains material concerning the use of such new drugs as cortisone, dihydrocortisone, butazolidene, hyaluronidase, and tolserol. The essentials of standard orthopaedic treatment remain the same. Forty-five illustrations have been added.

The book will serve well the general practitioner, house officer, and medical student in providing a convenient source of information, diagnostic and therapeutic, on orthopaedic conditions most commonly encountered. The descriptions are short and accurate. The subject matter is covered in chapters with anatomical headings, and in the form of complaints as presented by the patient, for example, "Limp in a Child", and "Weakness of Arm or of Leg in an Adult". Material is included which falls equally in the fields of neurology and orthopaedics.

The description of treatment is sufficiently detailed so that as a practical text the purpose of the book is accomplished. The author confines his discussion of treatment to those measures which can be performed in the office. There are sections on plaster techniques, shoe fitting and correction, as well as detailed descriptions of exercises which are frequently omitted in standard texts. The

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[1] BARR, J. S., and MARBLE, H. C.: Syllabus on Industrial Low Back Disability. Industrial Med. and Surg., **20**: 21-29, 1951.

Thornton Brown, M.D.

PHYSICAL THERAPY AFTER AMPUTATION. Margaret Bryce. Madison, University of Wisconsin Press, 1954. $1.50.

This pocket-sized paper-bound booklet is presented as an outline of basic techniques in the treatment of the unilateral lower extremity amputee, and is designed for use by physical therapists and students of physical therapy. A step-by-step presentation of bandaging, preprosthetic physical therapy, and gait training for the above-the-knee and below-the-knee amputee occupies the greater portion of the text. A short chapter is devoted to the fundamentals of the construction of prostheses. I feel that this book is definitely a worth-while compilation for the purpose for which it is intended, and that it may also be of value to the practitioner dealing with an occasional amputation.

Donald B. Slocum, M.D.

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Several points of criticism should be mentioned. Some of the diagrams are not sufficiently detailed to be helpful. The author provides many methods of treatment for a single condition, but neglects to evaluate their effectiveness for the less experienced clinician. It is my impression that local, sympathetic blocks, as well as manipulative treatment, are overemphasized as methods of choice.

John D. Leidholt, M.D.

LOW BACK PAIN AND SCIATICA. Louis T. Palumbo, M.D. Philadelphia, J. B. Lippincott Company, 1954. $3.00.

This little monograph covers this complex problem in less than eighty-nine text pages. Written primarily for the general practitioner, it discusses briefly the pertinent anatomical and pathological features, attempts to clarify the etiology of the syndrome, and presents a working diagnostic scheme similar to that offered by Barr and Marble[1]. A rationale and method of conservative treatment are presented in some detail, as well as the indications for surgical therapy.

In general, the approach to this complex problem is sound and the illustrations are of good quality. However, many statements appear with which one might take issue. For example, the impression is given that the "arthritides", including rheumatoid spondylitis, occur after the fifth decade, that chordomata involve only the sacrum, that "surgery is usually indicated to correct" spina bifida, that spasm of the sacrospinalis musculature may result in lumbar lordosis in intervertebral-disc lesions, and that the knee jerk is diminished or absent with disc protrusion at the fourth lumbar interspace. A clear distinction between malingering and psychosomatic or psychoneurotic back pain is not made in the text. Most authorities will agree that proved malingering is rare; yet, the text devotes half a page to psychosomatic back pain and three and a half pages to malingering. Much of what is described under the heading of malingering might have been better described under the former category. In spite of these criticisms, this little book fills a need presenting in concise and readable form a sound approach to this difficult problem which faces every practising physician.

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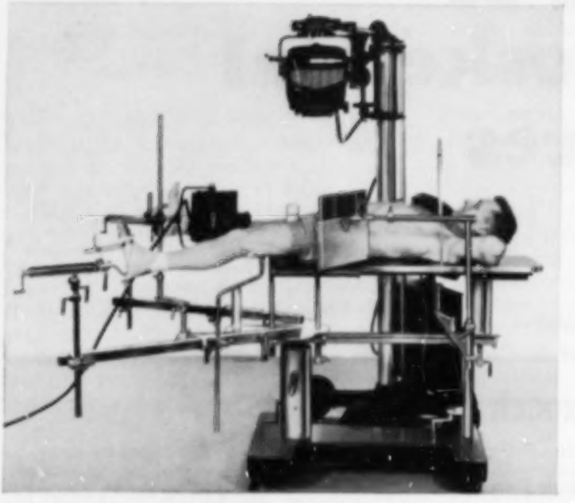

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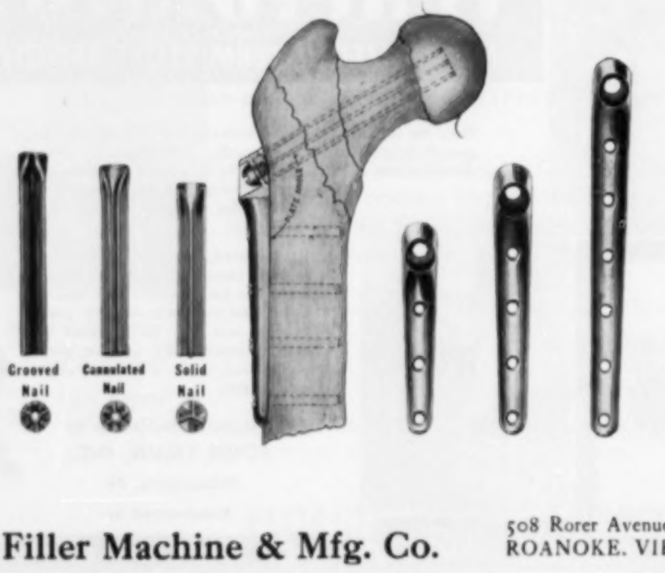

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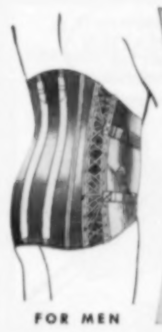

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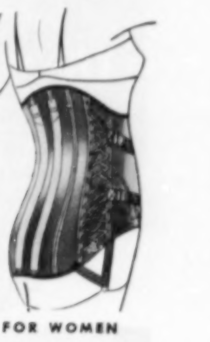

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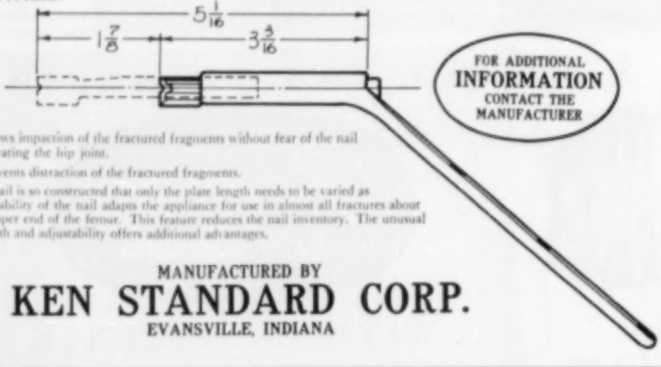

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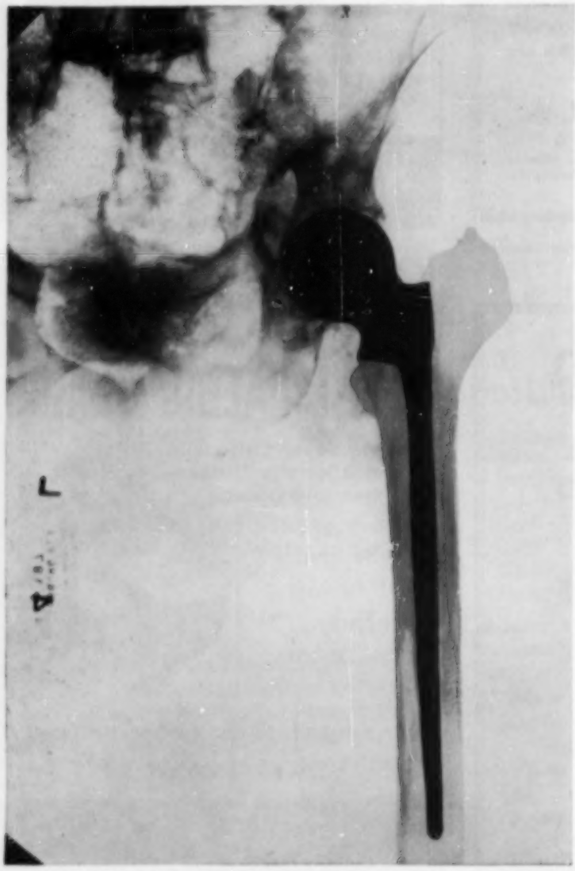

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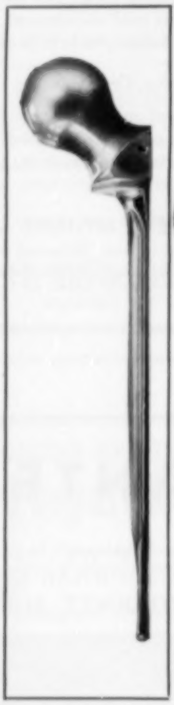

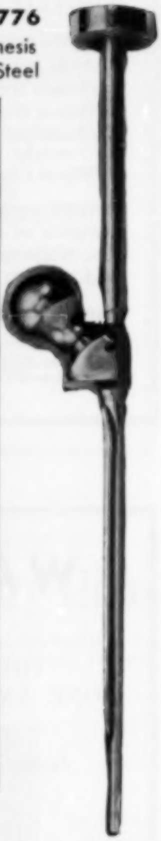

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